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THE NEW WATER-WORKS TUNNEL AT CINCINNATI, O., connecting the purification works on the Ohio River, at California, with the main pumping plant in the city, will be 7 ft. in diameter and 22,250 ft. long. It will be under a maximum hydrostatic pressure of about 43 lbs. per sq. in. Borings 1,000 ft. apart indicate that the tunnel will be entirely in a continuous limestone and shale formation, the maximum depth of rock above the roof being 20 ft. There will be three permanent shafts, 188, 163 and 200 ft. deep. The detailed bids for two sections of the tunnel, aggregating 7,100 ft. in length, were published under "Contract Prices," in our Supplement for July 12, 1900. The bids for the remaining portion, 15,150 ft. in length, were given in our issue of Oct. 11, 1900. Both contracts were awarded to W. J. Gawne & Co., of Cleveland, O., for the aggregate sum of $971,108, including permanent and working shafts. The tunnel will be lined with two rings of brick and at certain points "where the condition of the rock formation may require it, in the opinion of the Chief Engineer, the brick lining shall be hooped with steel rods, ¾-in. in diameter, spaced about 2 ft. apart." Mr. G. Bouscaren, M. Am. Soc. C.E., is Chief Engineer of the water-works improvements at Cincinnati, including this tunnel work. The new works, so far as then designed, were described in detail in our issues of Dec. 8, 1898, and April 26, 1900.

THE POLLUTION OF THE NAVESINK RIVER, by the sewage of Red Bank, N. J., must be stopped by Oct. 1, 1901, while certain individuals must stop pollution by June 1, 1901, according to an order of the New Jersey State Sewerage Commission.

A LARGE SEPTIC TANK PLANT AT COLUMBUS, O., is proposed for the partial purification of the sewage of that city. An outline of the scheme, with arguments in its favor, has been prepared by Mr. J. W. Griggs, M. Am. Soc. C. E., City Engineer of Columbus, for submission to the State Board of Health. There would be 20 concrete tanks, 50 × 150 ft. in area and 9 ft. deep, giving a capacity of about 500,000 gallons each. About 50% organic purification is expected, after which the effluent would be discharged into the river.

THE WATER AND LIGHT BUREAU of information has been organized with headquarters at Kansas City, Mo. The object of the bureau is to furnish legal and other information and aid to private water and light companies in Arkansas, Iowa, Kansas, Missouri, Nebraska and Oklahoma, particularly in the drawing of franchises and contracts and the defense of contract rights in the courts. Mr. Geo. M. Myers, Water-Works Building, Kansas City, Mo., is general manager of the bureau.

CUBA IS MAKING RAPID INDUSTRIAL PROGRESS, says a Havana correspondent of the New York "Evening Post." To meet the prospective sewering and paving of Havana, the council has decided to issue $25,000,000 5% bonds, which should bring par. The tobacco industry is rapidly increasing its acreage, and at Camajuarri a tobacco warehouse costing $51,000 is being built, while smaller warehouses are being erected everywhere. The sugar industry is also doing well. A project has been approved by Gen. Wood to expend $300,000 in deepening Cardanas Bay channel, so as to avoid the present inconvenience of anchoring at sea, 18 miles from the city. Secretary Caucio, in his annual report to the military governor, recommends the introduction of American money as a standard. At present four kinds of money are in use, to the annoyance of commercial interests.

LIQUID FUEL FOR STEAMERS, says the London "Times," has been lately tested by the steamship "Cowrie," which sailed from Koetei, in Borneo, to London, 9,250 miles, using only liquid fuel. The oil was reduced to spray by means of a steam-jet at the furnace door, coming from an oil-tank placed above the boilers. The "Cowrie" formerly used coal; but since the change in her furnaces, she needs only 6 instead of 16 stokers, and her speed has been slightly improved. The oil consumption was only 22 tons per day, as compared with 35 tons of coal formerly used. As a ton of oil occupies 35 cu. ft. against 45 cu. ft. for a ton of coal, the saving in bunker space was large. Oil is quickly put aboard the steamer; 300 tons having been pumped in in one hour. The Borneo oil forms an excellent fuel just as it comes from the ground, and it is delivered at 30 shillings per ton at Singapore and Hongkong; 32 shillings at Shanghai; 35 shillings in Japan and 50 shillings at Suez.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a rear-end collison on the Eastern Ry. of Minnesota, at West Superior, Wis., on Oct. 29. A freight train ran into a work train and two men were killed.

AN EXPLOSION in the Southern Coal Transportation Co.'s mines at Berrysville, Pa., on Nov. 3, resulted in the death of a large number of men. Twelve bodies have been recovered so far. The cause of the explosion has not been determined.

THE STEAMSHIP "ST. PAUL" met with a serious accident on Oct. 31 while on her way from Southampton to New York. The starboard propeller shaft parted and the propeller was lost. As the ship was pitching heavily at the time it is thought that the break was due to the racing of the engine. As a result of the break the engine was badly wrecked. Steam was shut off by a heroic member of the engine-room force before injury was done to the hull of the vessel or the longitudinal bulkhead, and the ship proceeded to port with the remaining engine.

THE WHITE STAR STEAMSHIP "CELTIC," now building at the Belfast yards of Harland & Wolff, will be 700 ft. long, 75 ft. beam, and 49 ft. deep. This exceeds the beam of the "Oceanic" by 7 ft., and the "Celtic's" gross tonnage will be 3,000 tons more. She is to have a speed of 16½ knots only, obtained with twin screws, and will be fitted with bilge-keels. The "Celtic" is intended for the intermediate New York service.

THE TORPEDO-BOAT DESTROYER "PERRY" was launched at the Union Iron Works, of San Francisco, Cal., on Oct. 27. This is one of the 16 destroyers ordered by the government two years ago, and is the first to be launched on the Pacific coast. Her general dimensions are like those of the rest authorized, or, water-line length, 245 ft.; extreme beam, 23 ft.; draft over top of her twin screws, 8 ft.; speed, 30 knots; coal carried, 100 tons; limit of cost, $295,000, with no bonus for excess speed. She will carry two 3-in. rapid-fire guns, five 6-pdr. guns and two 18-in. torpedo-tubes.

THE BERGER SUBMARINE TORPEDO-BOAT was tested at the Washington Navy Yard on Oct. 27. This boat is not intended to dive under the water, but to run with one-fourth of its volume appearing above the surface. This portion is filled with cellulose, so that if hit by a shell no serious damage will follow. All the vital parts are below the water line, as is the torpedo-tube. It is claimed that this form of boat permits more accurate steering than the Holland type. The model submitted did not develop any high power or speed, and it carried a very considerable wave, which is considered objectionable by naval authorities.

A RUSSIAN RAILWAY IN PERSIA is apparently the object of a late 5% loan guaranteed by Russia. The conditions are as follows: The loan is to run for 75 years, and the interest is to be guaranteed by the Persian customs operated by a branch of the Russian Imperial Bank, established at Teheran. It is also expressly stipulated that no new loan can be contracted for by the Persian government without the consent of this bank. This guarantee has been the subject of much comment, says "Le Genie Civile;" but the general opinion is that it will give to Russia a preponderating political and industrial influence in Persia, and especially favor the Russian schemes for building railways reaching the Persian Gulf and the Indian Ocean. During the last ten years Russia has had a monopoly in Persia in the proposed building of railways, though only two lines have been constructed; one uniting the Port of Recht, on the Caspian Sea, with Teheran; the other connecting Aschabad, a station on the Transcaspian Railway with Mechhed, on the Persian frontier. It is said that Russia has recently obtained a renewal of this monopoly for 15 years. A proposed extension of the Aschabad-Mechhed line would penetrate Persia and traverse the rich province of Chorassan, run along the borders of Afghanistan and Beloochistan, pass by Bampour and terminate at the port of Tschahbar, on the Indian Ocean.

A RAILWAY ACROSS GUATEMALA, from ocean to ocean, is the avowed object of a contract made between the Government of Guatemala and Snyder, Berthel & Co. This syndicate is to complete the Guatemala Northern Railway and control and operate it for ten years. The work is to be commenced by Dec. 1, 1900, and is to be completed by Dec. 31, 1902. Guatemala grants a subsidy of 200,000 acres of land and $4,000,000 gold 5% bonds. If the government does not take up these bonds at the end of the ten years, the American company becomes the absolute owner of the ceded lands and the railway. A steamship line, from Puerto Barrios to New Orleans, is proposed, as soon as the Trans-Isthmian line is completed, to compete for Pacific business.

RAILWAYS IN PORTO RICO are the subject of a concession made by the Executive Council on Oct. 29, to the North American Co. The grant calls for 300 miles of railway in the inner part of the island, operated either by steam or electricity.

THE BARREN ISLAND GARBAGE REDUCTION ACT, as it is popularly called, has been declared to be in violation of both the State and Federal constitutions, since it deprives the New York Sanitary Utilization Co. of property without due process of law and impairs the obligation of a contract without compensating the party injured. The act in question was passed at the last session of the New York legislature, and while it prohibited all reduction plants and like works in the borough of Brooklyn it was aimed specifically at the immense garbage reduction plant described in detail in our issue of Feb. 1, 1900. The provisions of the act in question were outlined in our issue of March 22, 1900, and discussed editorially in our issue of March 29, 1900.

EXAMINATION OF CANDIDATES for civil engineers of the Navy will be held Dec. 17, 1900, at the navy yard, Washington, and at the navy yard, Mare Island, Cal., and candidates to whom permits may be issued should present themselves before the medical board at 10 o'clock a. m. that day.

The following rules are adopted governing appointments to the corps of civil engineers in the Navy:

No person shall be appointed who is less than 28 or more than 35 years of age. Candidates for appointment shall be examined as to their physical fitness by a board of medical officers of the Navy, and as to their mental and professional qualifications by a board of such officers as the Secretary of the Navy may designate for the purpose. The physical examination shall precede the mental and professional, and if a candidate is found physically unfit for appointment he shall not be further examined. Applications for permits to be examined must be made to the Secretary of the Navy. Each applicant must present testimonials as to character, evidence of American citizenship, evidence of having received a degree in the civil engineering course of some professional institution of good repute, and a record of at least five years' practical experience as a civil engineer and three years' responsible charge of work. The mental and professional examination will be competitive, and in writing, and will comprise the following subjects: Testimonials and adaptability; English grammar and composition; elementary physics; elementary geology; drawing; arithmetic; algebra; geometry; trigonometry; analytical geometry; differential and integral calculus; applied mathematics, including mechanics of solids and fluids and strains in structures; construction materials; engineering constructions, such as workshops, chimneys, steam and electrical machinery, quay walls, wharves, dry docks, sewers, yard railways, pavements, water distribution, foundations, etc.; surveying (topographical, trigonometrical, and hydrographical) and mapping; instruments, their use and adjustment. Candidates who pass satisfactorily will be arranged by the board in the order of their relative merit as determined by such examination; but no candidate will be considered as having passed a satisfactory examination who does not attain a general average of 75%, and an average of at least 80% in the following subjects: Applied mathematics, constructional materials, and engineering construction.

EXPERIMENTAL STRIPS OF WOOD BLOCK PAVEments are to be laid on portions of Tremont St., Boston, by Mr. Bertrand Wheeler, Superintendent of streets. Parallel with the wood will be strips of asphalt.

THE POPULATION OF THE UNITED STATES has been officially announced by the Census Bureau as amounting to 76,295,220, for the 45 states and the territories, including Hawaii. This represents a gain of 13,225,464 since 1890, or an increase of 21%. The population of the state of New York is 7,268,009, as compared with 5,997,853 in 1890. In the 45 states alone there are 74,622,907 inhabitants, as compared with 62,116,311 in 1890.

THE WATER SUPPLY TUNNELS OF CHICAGO.*

II.

LAKE VIEW TUNNEL.

The water supply of the former city of Lake View was originally taken from the lake by submerged pipes, as already noted, but in consequence of the inadequate supply and the unsatisfactory quality of the water furnished by the short submerged intake pipes, the authorities decided to construct an intake tunnel. The first contract was awarded by that city to Shailer & Schniglau, of Chicago, on May 24, 1889, and called for 5,000 lin. ft. of brick tunnel of 6-ft. inside diameter, with 8-in. lining, and with shore shaft, intake shaft, intake crib, lighthouse and electric lights, for a bulk sum of $159,650. For an extension beyond 5,000 ft., limited to 500 ft., a price of $16.85 per foot was to be paid. For a difference in depth either way of 80 ft. below datum, $49.75 per lin. ft. for the shore shaft was to be added or subtracted from this bulk sum. For a difference either way from a depth of 79 ft. below datum, $144 per lin. ft. for the lake shaft was to be added or subtracted from the bulk sum.

The shore shaft was commenced in June, 1889, and the tunnel was commenced in July. Later on it was proposed to make the tunnel 5,000 ft. longer, but this was abandoned as being too expensive. The town was annexed to Chicago, however, that same year, and the city council of Chicago decided that the tunnel should be extended. The second contract was made Sept. 23, 1890, and called for an extension of the 5,500 ft. provided for in the first contract, the extension to be 4,500 ft. in length, and 6 ft. in diameter. For the necessary additional height of the crib, on account of the extension of the tunnel, the contract called for an extra sum of $11,116. In consideration of the longer haul, taking material in and bringing excavated material out of the tunnel, the larger plant necessary for ventilation, etc., an average price of $18.50 per lin. ft. was to be paid for the 4,500 ft. of tunnel, arranged on the following basis:

	Per lin. ft.		Per lin. ft.
First 500 ft.	$16.85	Sixth 500 ft.	$18.75
Second 500 ft.	17.03	Seventh 500 ft.	19.43
Third 500 ft.	17.31	Eighth 500 ft.	20.21
Fourth 500 ft.	17.69	Ninth 500 ft.	21.09
Fifth 500 ft.	18.17		

The tunnel construction commenced with a shaft on shore, from which the tunnel was driven eastward under the lake. Some 6,300 ft. of tunnel was thus built before any work was done from the Two-mile crib, which meanwhile had been built and placed. Owing to the slow progress made on the tunnel, the poor quality of the water pumped through the old intake pipes and the trouble from ice in the winter time, it was decided to place a temporary crib over the tunnel; sink an intake shaft with gates; put a bulkhead in the east drift close to the shaft, and then build the remainder of the tunnel from the outer crib. This intake is 6,032 ft. from the shore. The temporary crib was finished and the shaft connected with the tunnel April 2, and water was let in April 6, 1892.

The plans and specifications specified that the bottom of the inside surface of the west end of the tunnel should not be less than 80 ft. below city datum, and have a gradual inclination upward of 1 ft. per mile to the eastern terminus. This grade, however, was changed to 70 ft. below datum before work was commenced. The heading running eastward from shore had to be driven almost constantly through more or less rock, making progress very slow and the cost great. In the early part of October, 1891, the face of the tunnel then being about 4,920 ft. from shore, the contractors were ordered by the City Engineer to change the grade so as to rise out of the rock. The last 1,000 ft. of the shore heading was, therefore, built to an inclined grade upward until an elevation of 57 ft. below datum was reached at the end of the shore heading, 6,300 ft. east from the shore shaft.

Tunneling from the outer crib commenced in November, 1892. The grade as established by the engineer at this point is 63.5 ft. below datum, or 6.5 ft. lower than the east end of the shore heading. The work proceeded through good soil at a slightly inclined grade upward until a distance of 1,260 ft. west from the crib was reached, when on Feb. 15, 1893, the water began to come in through a sand and gravel pocket in the roof of the drift in such quantities as to flood the pumps and fill the whole tunnel and shaft with water up to the level of the surface of the lake. Attempts to pump the water out were unsuccessful, and it was then decided to resort to compressed air for the purpose of driving the water out of the tunnel. On March 7, 1893, the City Engineer instructed the contractors to proceed with the installation of the necessary plant. Several thousand cubic yards of clay were dumped over the break, and by means of the compressed air plant the water was forced out of the shaft through a pipe reaching up through the air lock. When the water in the shaft had been lowered so as to create a head of about 30 ft. the air pressure was reduced. It was then found that the leak was very small, since the water remained at nearly the same level. A few more scow loads of clay were then dumped, which almost stopped the leak.

According to the diver's report on his first examination of the bottom of the lake, the hole was supposed to be quite small. It was, therefore, considered safer to pump the water out of the tunnel than to force it by air pressure, since it was feared that when the compressed air reached the face it would find its way out and open up the hole. The air lock was, therefore, taken out and the pump placed in the shaft. All went well until the water in the shaft had been pumped out, so as to reach the eye of the tunnel, which was at 11 a. m., June 22, 1893, or four hours after commencing pumping, when in an instant the water began to rise and filled the shaft in a few minutes. On June 23, a diver was engaged to examine the ground at the location of the leak, and he reported that there was a large opening in the lake bottom about 8 ft. in diameter.

After the failure to stop the leak at the end of the west drift, from the outer crib, it was decided to build a temporary pile crib adjacent to the inner Lake View crib, sink a shaft and commence to build a tunnel at a lower level, so as to be entirely in rock, out toward the outer crib. This work was commenced early in August, 1893. After the completion of the crib, the sinking of the shaft progressed more or less satisfactorily until the required depth was reached. Tunneling eastward commenced in February, 1894. It was first intended to connect this tunnel with the west end of that part built from the outer crib, but it was finally considered entirely too risky. The 1,250 ft. of flooded tunnel was, therefore, abandoned, and

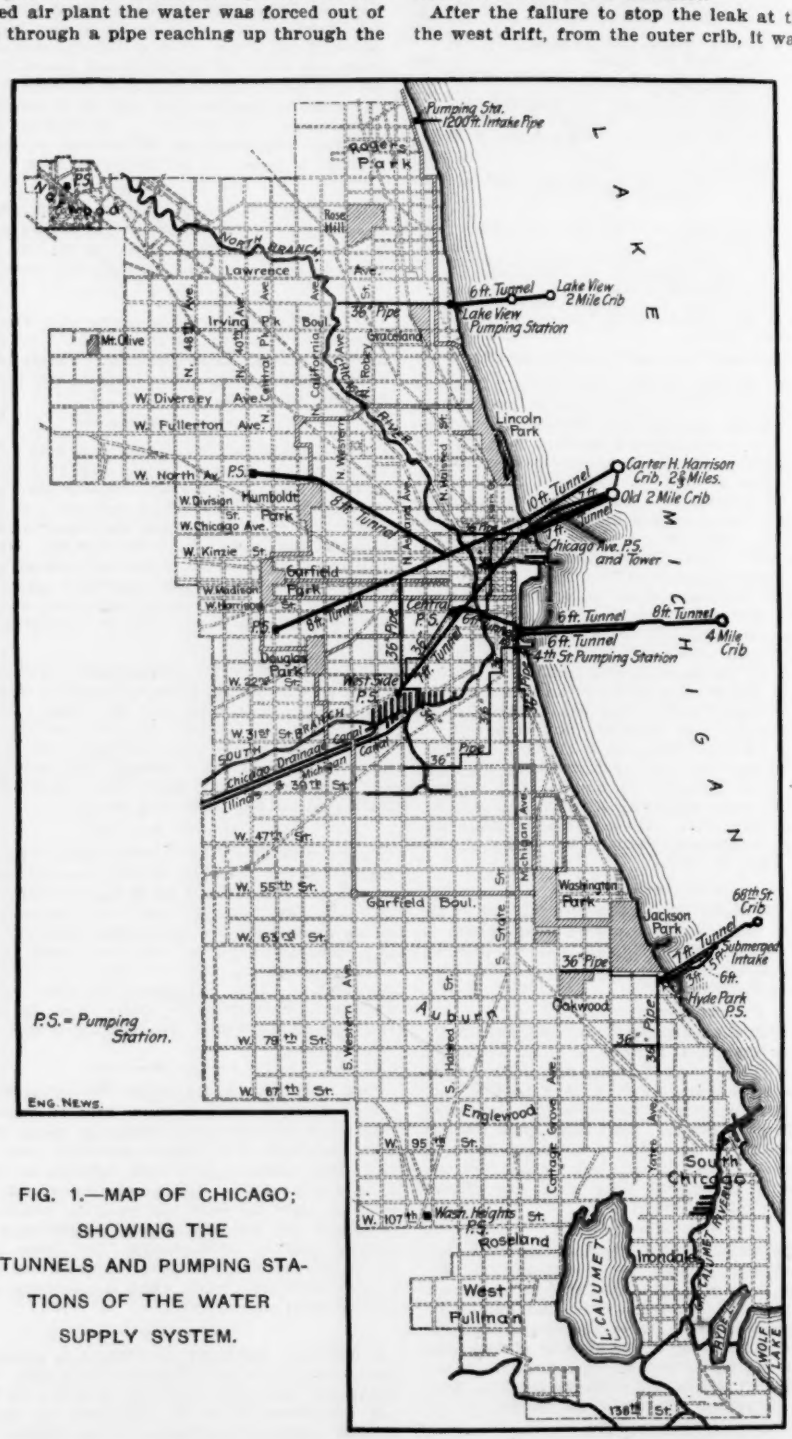

FIG. 1.—MAP OF CHICAGO; SHOWING THE TUNNELS AND PUMPING STATIONS OF THE WATER SUPPLY SYSTEM.

*The first part of this paper was published in our issue of Oct. 18.

the line was diverted so as to avoid the quicksand and to connect with the shaft at the outer crib.

At the expiration of the second contract, there remained about 2,000 ft. of tunnel to be built, and by agreement between the contractors and the city, the former were to receive $20 per lin. ft. for this remaining part of the tunnel.

At the beginning of the year 1895 only 2,205 ft. of tunnel from the center of the shaft at the intermediate crib had been constructed, and 1,959.8 ft. were constructed during 1895. The abandoned spur running west from the outer crib was bulkheaded off by placing alternate piles of bags of cement and sand for a distance of 14 ft. The water was then pumped out of the shaft and a brick bulkhead 4½ ft. thick built near the shaft. The shaft was then sunk to the level of the new tunnel and connection between the tunnel and the shaft made December 27, 1895. The connection between the tunnel leading to the pumping station from the intermediate crib, through which the water was being taken, and the tunnel running from the working shaft to the outer crib was all that was left to be constructed. During January, 1896, all the brickwork in the tunnel leading to the outer crib and the additional depth of shaft at the outer crib was finished and pointed up and the tunnel cleaned out.

A drift was then run from the working shaft at the intermediate crib to a point directly under the center of the intake shaft. The contractor's men, except a few necessary to keep the tunnel clear of water, were then laid off until the city was ready to have the connection made. In order to make this connection it was necessary to provide a temporary intake for the Lake View pumping station. It was at first intended to utilize an old 20-in. pipe leading from the shaft near the pumping station out into the lake, but an examination by a diver disclosed the fact that the pipe was buried in and filled for a long distance with sand and otherwise defective, necessitating considerable expenditure of money to make it serviceable. It was, therefore, abandoned and a new 36-in. pipe was laid from the shore shaft to a point in the lake about 360 ft. from shore. This required 600 ft. of cast-iron pipe. The land portion, 240 ft., was laid by the city. The lake portion, 360 ft., was laid by the Dunham Towing & Wrecking Co., of Chicago. A plug was placed over the eye of the tunnel in the shore shaft, the gates of the inner crib were shut down June 30, and the pumping out of the old tunnel commenced. This connection was finished and the gates at the outer crib opened (admitting water to the tunnel) July 12, 1896. Fig. 3 is a plan and section of the Lake View tunnel.

This extension did not add to the amount of the water supply, but greatly improved the quality of the water supplied to that section of the city which is dependent upon the Lake View plant. Mr. Bernard Feind was Assistant City Engineer during a large part of the work, and Mr. R. B. Wilcox was Assistant Engineer in charge of the work.

HYDE PARK, OR 68TH ST. TUNNEL.

In 1884-85, the village of Hyde Park had a tunnel built, and established a submerged intake 5,036 ft. from the shore shaft. The bottom of the tunnel was 49 ft. below datum at the shore shaft and 28 ft. below the top of the intake shaft, which was 5 ft. above bed of the lake, in 27 ft. of water. The tunnel, marked No. 1 on the plan, Fig. 4, was 6 ft. 3 ins. in diameter, and the construction of the intake was described in our issue of Jan. 12, 1889. This 6-ft. tunnel was driven with difficulty to the point (A) where quicksand was encountered. This was thought to be a pocket, and the tunnel was diverted for some distance, when the original course was approximately resumed. The abandoned drift was closed with a bulkhead. The same material was again encountered, however, on the new line, but in this case the tunnel was successfully pushed throught it for a distance of 600 ft., when good ground was found, and the tunnel was continued in a direct line towards the intake.

The original design of the Hyde Park tunnel included a submerged intake, as already noted, and in 1884 a contract was let to Hean & Corbyn, for the construction of a temporary crib for the intake shaft. On Oct. 8, while the crib was being sunk, a violent storm destroyed the temporary working platform, and eight men were drowned, including both contractors. The village then undertook the work, Mr. C. McLennan being the engineer in charge. When the shaft was finished and tunneling commenced, a transverse seam caused an extensive leak. Attempts to close the seam by filling in on the bed of the lake were unsuccessful, and it was found impossible to pump out the water. At the same time water leaked from the heading into the completed part of the shore tunnel. The shaft and air lock were therefore removed from the submerged intake crib, and a cover was bolted over the opening. The air lock was taken down the shore shaft and installed within 5 ft. of the bulkhead at the end of the shore tunnel. Under a pressure of 22 lbs. the bulkhead was removed and work was pushed forward. Air escaped through the roof, by cavities caused by the abandoned excavation beyond the bulkhead, and these were filled with brick masonry. The arch centering was of boiler plate, 24 ins. wide and 6 ft. long, with 2-in. angles on three corners. When bolted together these formed an exterior arch resting on the undisturbed hardpan below the invert. This held the heading while the walls were extended, which was done every 4 ft. Connection was successfully made with the part started from the crib, but when the air pressure was taken off, the leakage beyond the lock was more than could be taken care of by the 6-in. drain pipe through the lock. In the spring of 1885, the bed of the lake was covered with clay, spread by a diver, especially where air had escaped when working. The valve in the air lock was then opened and the water drawn off. The men then reached the crib, removed the filling of sand and clay, and built a brick shaft in it from the tunnel to the bed of the lake. The air lock was then removed and the tunnel cleaned out.

In 1892, it was decided to construct a 7-ft. extension of this tunnel to an intake crib 2 miles from shore, and the contract for this was let to Lydon & Drews, of Chicago, as the lowest bidders. As the water supply for the Columbian Exhibition was to be drawn from this tunnel, it was decided to place an intermediate crib and shaft 6,500 ft. from shore, in order to allow of the prosecution of the work from three headings.

When the heading from the intake crib had advanced about 700 ft. westward, the roof collapsed and the tunnel was filled with water. The break was filled by dumping clay in the lake, an air lock was installed on the shaft, and the water was pumped out, when the wooden cover of the shaft caught fire, and was destroyed. Iron covers were then made for the openings, the air lock was again installed, and the tunnel again pumped out. The original drift was abandoned, and a bulkhead built at B. The new work was run north for a short distance, and then west again, parallel with the original line.

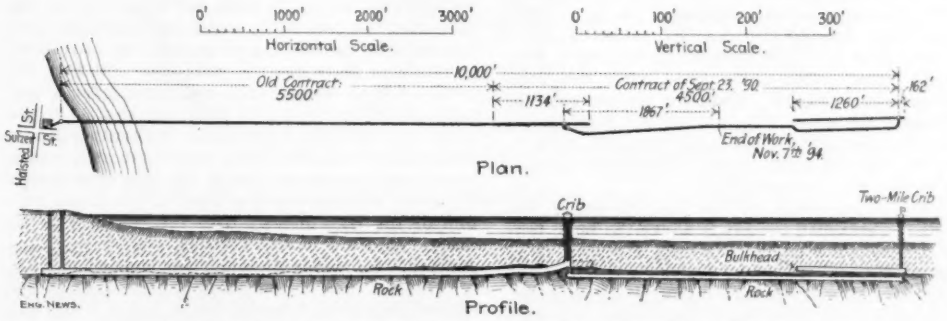

FIG. 3.—PLAN AND PROFILE OF LAKE VIEW TUNNEL, CHICAGO.

Similar experiences were met with in driving the tunnel east and west from the intermediate crib. The work was continued eastward as far as the point marked (C), when bad ground was encountered. The end of the drift was closed, an air lock put in a short distance back, and the tunnel run north, when the original line was resumed as far as (D). It was then again diverted to avoid the bad ground previously struck by the tunnel from the intake crib at (B), and also to meet the tunnel as diverted west of this point. West of the intermediate crib, work was continued for about 1,650 ft. when (in June, 1893) bad ground was encountered and the drift was closed by a bulkhead at (E). Beginning again some distance back from the bulkhead, and about 1,200 ft. east of the submerged intake, the work was driven south to (F), an air lock being put in at (G). But in December, 1893, a break occurred near the junction of the old and new work and the tunnel was flooded. An air lock was then placed on the intermediate shaft, an air lock built in the tunnel at (H), and the end of the work at (F) closed by a bulkhead.

As described in an article by Mr. John Ericson, now City Engineer, in our issue of May 31, 1894, the original plan was to build the new 7-ft. tunnel westward to a point near the submerged intake of the old 6-ft. tunnel, and then to connect the two. This would have neecssitated pumping the water out of the old tunnel. To supply water to the pumps during this time, a 5-ft. shore tunnel was

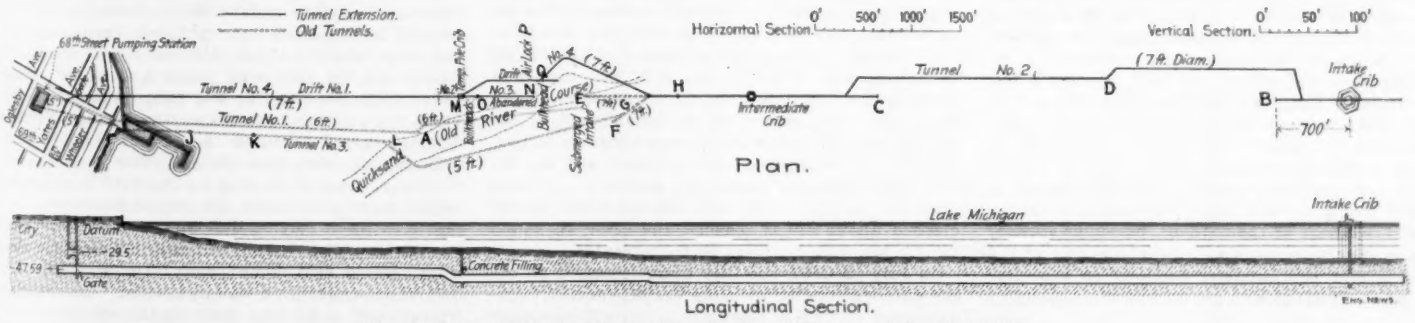

FIG. 4.—PLAN AND PROFILE OF HYDE PARK TUNNEL, CHICAGO.

built terminating at a crib (J), 900 ft. from the shore. The pollution due to filling along the shore, however, and the serious difficulties encountered, led to this plan being abandoned. As the 7-ft. tunnel could not be completed in time for the Columbian Exhibition, and as there was increasing pollution of the water along the shore, the 900-ft. intake was extended 600 ft. further, to a temporary intake crib (K), 1,500 ft. from the shore shaft. This was then extended, with a view of connecting it with the abandoned 7-ft. drift at (F). At (L), however, the quicksand was again encountered, the drift was closed, and the line run southeast until good ground was struck, when it was again turned towards (F), work being stopped when within 50 ft. of the end of the 7-ft. tunnel, which had been stopped at (F). The eastern end of the tunnel was then pumped out, and the connection made between the 5-ft. and 7-ft. tunnels.

The new system was completed in June, 1894, when water was let into the 7-ft. tunnel, and the old and new systems were connected by a 5-ft. lateral tunnel under Yates Ave. After this time, therefore, the 68th St. pumping station received its supply of water through the old 6-ft. tunnel from the submerged intake, and through the 7-ft. and 5-ft. tunnels from the new "Two-mile" intake, 10,000 ft. from the shore shaft.

In the construction of the 7-ft. tunnel, it was decided to establish the grade above the rock, taking the risk due to a diminished depth of cover over the tunnel. This was done on account of the heavy expense and the slow rate of progress which would have been involved if the tunnel had been kept in the solid rock. The same plan had been adopted in the Lake View tunnel, as already noted. The grade was established at 59.6 ft. below datum, leaving a cover of 21 ft. of soil, but at some places the depth of cover is only 14 ft. Work progressed at the rate of about 21 ft. per day, but after the work had progressed about 800 ft. from each shaft, water broke into both drifts, and it was necessary to introduce air locks and prosecute the work under air pressure. Numerous difficulties were encountered in this work, as above noted, and the methods by which they were overcome were fully described in our issues of May 31 and July 26, 1894, in which numbers, also, the intake crib was described. The tunnel was completed in May, 1894. Mr. L. H. Clarke was City Engineer from the time of letting the contract until Jan. 1, 1893. Mr. Dion Geraldine was then City Engineer, and Mr. Bernard Feind was Consulting Engineer until May, after which Mr. Samuel Artingstall was City Engineer; Mr. John Ericson, then Assistant City Engineer, was in charge of the tunnel work.

The capacity of the 5-ft. tunnel, No. 3, was not sufficient, and it became necessary to draw part of the supply from the submerged intake of the 6-ft. tunnel, although this intake was considered to be too near shore for safety. In 1895, therefore, Mr. Jackson, City Engineer, recommended that a 7-ft. tunnel, 5,000 ft. long, should be driven from a new shore shaft to connect with the 7-ft. tunnel No. 2, already completed from the intake crib to a connection with the 5-ft. tunnel. This new tunnel is marked No. 4 on the plan, connecting with the Yates Ave. shaft of the 68th St. pumping station, and was considered necessary for the supply of the southern and southeastern portions of the city. This was completed and put in operation early in 1898.

The contract for this 7-ft. tunnel extension, No. 4, was awarded to Ross & Ross, of Chicago, on Sept. 1, 1896. The work called for by the contract for this extension consisted of the construction of about 5,000 ft. of 7-ft. tunnel from a shaft located at the intersection of Yates Ave. and 68th St. to the stub end of the existing 7-ft. tunnel running westward from the Two-mile crib. This extension was also to be continued by means of a 5-ft. tunnel from this shore shaft to the existing Yates Ave. shaft at the 68th St. pumping station.

For the purpose of hastening the completion of the work, the contract included the construction of a temporary pile-crib and working shaft (M), to be located about 3,500 ft. from shore. The contractor was also required to isolate and drain the old 7-ft. tunnel, in order to make proper connection with the new tunnel.

Work on the shaft was commenced Sept. 7, 1896. Work on the pile-crib was commenced Sept. 20, but on account of unfavorable weather the crib was not ready for occupancy until Dec. 15, at which time work on the shaft was commenced. At the close of the year 1896 there had been constructed as follows:

Drift No. 1, running east from shore shaft	2,014.0 ft.
Drift No. 2, running west from lake shaft	68.0 "
Drift No. 3, running east from K shaft	38.0 "
Back drift running west from shore shaft	16.0 "
Length of shore shaft constructed	63.6 "
Length of lake shaft constructed	69.5 "

The back drift above mentioned is a stub tunnel 7 ft. diameter and 240 ft. long, running west from the shore shaft towards the pumping station, and designed to connect at some future time with a new suction well.

The work was carried on satisfactorily in drifts Nos. 1 and 3 through a hard seamy clay and dry loam with occasional pockets of quicksand, until Feb. 9, 1897, when, in Drift No. 3, at a point 750 ft. east of the lake shaft, water, sand and gas were encountered in the upper quarter in sufficient quantity to drive out the workmen. On Feb. 22, after working through this bad ground for a distance of 29 ft. (or 759 ft. from the shaft), to the point (N) the lake broke in and in twenty minutes Drifts 2 and 3 and the shaft were filled with water. Work was then suspended at the crib until March 18, when, with the aid of a diver, a hole in the bottom of the lake directly over the tunnel was located. Into this cavity 1,500 cu. yds of clay were dumped. On March 23, work was stopped in Drift 1, 3,784 ft. east of the shore shaft, as there remained only 97 ft. between Drifts 1 and 2, the latter being filled with water. On March 29, the contractors commenced to pump out the lake shaft and Drifts 2 and 3. This was accomplished by March 13, and a brick bulkhead (O) was put in Drift 3 at a point 110 ft. east of the shaft. It was then decided to abandon Drift 3 and to make a detour to the north until a point 150 ft. from the original line was reached, thence to run in a direction parallel to the original line, and finally connect with the existing tunnels at the junction of the 7-ft. and 5-ft. tunnels. Drift No. 4 was started on this line May 19. In the meantime connection was made between Drifts 1 and 2. During April the back drift was extended to a point 240 ft. west of the shore shaft, and in May a cast-iron gate was placed in the short shaft to shut off the back drift.

Work progressed satisfactorily in Drift No. 4 until June 22, 715 ft. having been built. At this time the contractors were ordered to put in an air lock and install a complete air plant, so as to be prepared to adopt the pneumatic system of tunneling in case bad ground should be encountered. These orders the contractors refused to obey unless an extra price was paid, claiming that they had built the number of lineal feet of tunnel called for by their contract. Work in this drift was then suspended. At this time 5,694 ft. of tunnel had been completed. On account of the breaking in of the lake in Drift 3, it was found impracticable to proceed on the line as originally planned, and the detour was made as heretofore outlined. By this plan the length of the 7-ft. tunnel would be increased about 970 ft. beyond the 5,300 ft. called for by the specifications and contract.

On July 12, 1897, the City Council passed an order authorizing and directing the Mayor and Commissioner of Public Works to make all necessary arrangements for the completion of the 7-ft. tunnel from a point 5,758 ft. west of the Two-mile crib to the Yates Ave. shaft at 68th St., as per order of Council of July 27, 1896. The necessary appropriation was also made for this work. In accordance with this order, a contract was let on Aug. 3, 1897, to Ross & Ross, for the construction of 1,450 ft., more or less, of 7-ft. tunnel at the rate of $27 per foot, according to the specifications which had governed the work done under the original contract; all other work to be completed according to the terms and at the price of the original contract. In July, 84 ft. of the 5-ft. tunnel to connect the shore shaft with the existing Yates Ave. shaft was constructed, and 10 ft. of this tunnel remained to be done.

Immediately after the signing of the second contract, work was commenced on an air lock in Drift No. 4. This lock (P) was completed Aug., 1897, and work in this drift was resumed. At station 9+58 the stratum of torpedo sand was again encountered. Air pressure did not prove effectual, as the air escaped through the sand and thence to the shaft through the abandoned Drift 3. A safety bulkhead (Q) was put in at station 9+53, this bulkhead being provided with a door to be closed in case of emergency. This torpedo sand continued in the roof until Sept. 16, when at station 20+47 the lake again broke in. The door in the bulkhead was closed and the tunnel to the west of the bulkhead was thus saved. Another detour to the north was then decided on, beginning at station 15+60. On this line the work continued without any trouble until station 19+39 was reached, where the torpedo sand was again encountered. Another safety bulkhead was then constructed at station 19+24. This time the air did not escape and very little trouble was experienced.

On Dec. 23, the work was reaching a point where it was deemed advisable to discontinue operations in the 7-ft. tunnel, until the old tunnels had been pumped out. The contractors were accordingly notified on that date not to carry the new 7-ft. tunnel closer than 100 ft. from the point where necessary connection with the old tunnels would be made. They were also given certain instructions as to the methods to be pursued in isolating and draining the existing tunnels. The following day, Dec. 24, without previous notice, the contractors bulkheaded the face at station 20+03, and suspended all operations, claiming that the number of lineal feet called for by their second contract had been constructed, although there yet remained to be completed (under the second contract) 147 ft. of 7-ft. tunnel to connect with the old tunnel, and (under the first contract) 10 ft. of 5-ft. tunnel to connect with the Yates Ave. shaft. They refused to proceed with the work unless the city agreed to pay an additional price for the work remaining to be done.

On Jan. 8, 1898, the contractors were formally notified to proceed with their work, and to complete it as provided by the specifications and contracts. The contractors refusing to comply with the orders of the Commissioner of Public Works, the city took possession of the tunnel and plant on Jan. 18, in accordance with an order passed Jan. 17 by the City Council, which authorized the Commissioner of Public Works to take possession of the tunnel and the contractors' plant, employ necessary labor and complete the work. Preparations were at once made at the intake crib to pump out the tunnels then in use, which was necessary before connection between the new and existing tunnels could be made. On Jan. 26, the gate in the 5-ft. tunnel at the shore end was closed and the attempt was made to take water through the submerged intake, 5,000 ft. from shore. On account of the large amount of ice, this was found impracticable, and the gate was raised and water again taken from the crib. It was then decided to wait until the ice was out of the lake before another attempt should be made. Later, the old 7-ft. and 5-ft. tunnels were isolated, and after considerable difficulty, drained, so that on April 17 the miners began excavating, and the connection was completed, without further difficulty on April 29. The tunnel was then cleaned out, and the shaft at the intermediate crib domed over. On May 21, the 5-ft. shore connection was completed. The tunnel was allowed to fill with water to the lake level and the brickwork cut out of the Yates Ave. shaft by a diver, thus allowing the water to pass through the new system of tunnels to the pumping station.

The shore shaft was then domed over and the iron bulkhead put in place, and the old submerged intake entirely isolated. Later, under another contract, the intermediate working crib was entirely removed by Oct. 1. The total length of 7-ft. tunnel constructed was 7,316.4 ft., and of the 5-ft. tunnel 102 ft. The total length of tunnels in use from the Two-mile crib to the 68th St. pumping station was then as follows: 11,167 ft. of 7-ft. tunnel and 8,132 ft. of 5-ft. tunnel. There were also 5,026 ft. of 6-ft. tunnel leading from the submerged crib to the pumping station. By the addition of the new 7-ft. tunnel the capacity was greatly increased, so that the submerged intake crib was abandoned. The loss of head through the system was thus greatly decreased, inducing

greater economy in the operation of the pumping engines, and also providing sufficient water for another engine to be installed in the future. The entire supply of the 68th St. pumping station is now taken from the 68th St. crib. Mr. R. B. Wilcox, assistant engineer, was in charge of this extension work until March, 1898, when, having resigned, Mr. Paul G. Brown, assistant engineer, was given charge, and under his immediate supervision the work was completed.

NORTHEAST TUNNEL.

A tunnel extending from a shore shaft four miles east under the lake, and westward under the city to a new pumping station near Humboldt Park, was authorized by the City Council on July 30, 1894, Mr. Samuel G. Artingstall being then City Engineer. Later, this plan was modified, two land tunnels being adopted, extending to pumping stations at Central Park Ave. and Fillmore St., and Springfield Ave. and Bloomingdale Ave. In 1896, the contract for the lake tunnel and intake shaft was let to the FitzSimons & Connell Co., of Chicago. The tunnel is 10 ft. wide and 10 ft. 2 ins. high, with a 12-ft. intake shaft in a crib 2⅝ miles from shore. The land tunnels are 10 ft. and 8 ft. diameter, and will convey the supply to the pumping stations, each of which will have four vertical pumping engines of 20,000,000 gallons daily capacity each. The lake and land tunnels, intake shaft and crib, and the pumping stations, were described and illustrated in detail in our issue of Aug. 31, 1899.

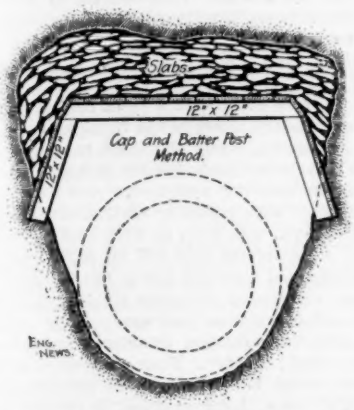

Fig. 5.—Excessive Excavation of Tunnel Section.

The lake tunnel is 2⅝ miles long, and was driven mainly through different grades of clay, with occasional pockets of sand, some containing gas. Two breaks occurred, and made it necessary to employ the pneumatic system in order to pass through the treacherous material. It was commenced in July, 1896, and completed in January, 1899. On the land tunnel, Section No. 1 (10 ft. diameter, 8,666 ft. long) was in a hard, tough, gravelly clay, necessitating the continual use of dynamite. Small sand and gas pockets were encountered, but did not retard the progress of the work, and the only difficulty met with was a pocket of quicksand, 513 ft. from the shore shaft. The average rate of progress was 17 ft. per day of 24 hours. Section No. 2 (8 ft. diameter, 3.76 miles long) is in rock and hard clay, the latter having occasional seams and pockets of loam which caused considerable caving. Section No. 3 (8 ft. diameter, 4.2 miles long) was worked from five shafts, all but one of which were sunk without difficulty and timbered to the rock. When the excavation for the shaft at Wabansia Ave. and Monticello Ave. had reached a depth of 38 ft., a vein of quicksand was struck, and before it could be controlled, the rush was so great that the brickwork was badly cracked. This shaft was being lined with brick as it was sunk, and it was decided to be more economical to abandon this and sink another shaft at Wabansia and Central Park Aves., one block farther east. This, like the others, was timbered to the rock, which was reached at 28 ft. below datum. The shaft is 100 ft. deep.

Particular interest is attached to Sections 2 and 3 of the land tunnels, owing to litigation between the city and the contractors, who were Mr. Joseph Duffy and Messrs. Weir, McKechney & Co., respectively. The former, however, completed his work in April, 1900, but the latter abandoned the work. In the case of Section 3, the court awarded the sum of $540,000 to the contractors, and the Commissioner of Public Works then cancelled the contract and directed the City Engineer to have the work done by day labor. Mr. Paul G. Brown was the engineer in charge. Work was commenced under his direction in July, 1899, and was prosecuted successfully at a much greater rate than that made by the contractors. One of the principal complaints against the latter was the unnecessary amount of excavation. In typical cross-section the excavation as made by the contractors was V-shaped, with a curved bottom and flaring sides, the roof being sometimes 35 ft. above the masonry of the tunnel. Short inclined posts, 12 × 12 ins., were let into the sides, near the level of the top of the masonry, and these supported caps 12 × 12 ins., above which were the timber lagging. The masonry was then built in this big excavation, and a considerable amount of brick masonry at $6 per cu. yd. was thus required. Under this system, which is represented in Fig. 5, the progress made was but about 8 ft. per day. The price, under the award of the court, was $68.45 per ft. in clay, and $91.19 per ft. in rock.

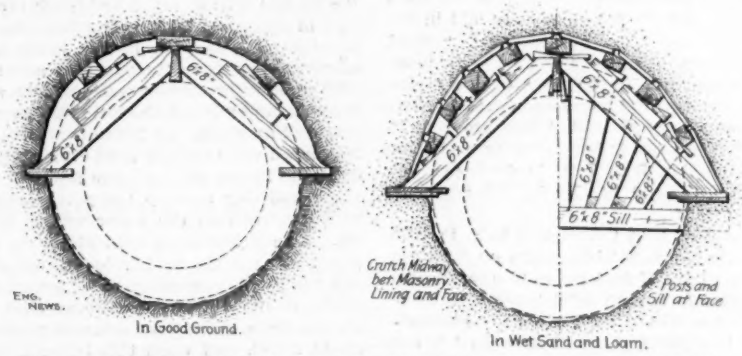

FIG. 6.—CRUTCH SYSTEM OF TIMBERING IN TUNNEL EXCAVATION.

Under the direction of Mr. Brown, the crutch and crown-bar system of timbering was adopted, and the circular excavation was but little in excess of the outside diameter of the tunnel. At about the level of the center of the tunnel, horizontal wall plates or longitudinals were let into the sides of the excavation, and upon these rested pairs of timbers 6 × 8 ins., forming inverted Vs, the apex supporting a longitudinal cross timber. Upon the outside of these timbers was placed blocking to support longitudinal timbers supporting the sides of the excavation. The number of these timbers varied with the character of the ground. A sill, 6 × 8 ins., was placed at the face and the face bulkheaded to form a bearing for the sill. One set of crutches was used midway between the finished face of the work to support the bars. The rear ends of the bars were carried by the masonry, and the front ends by posts at the face. The general arrangement is shown in Fig. 6, and it will be seen that all the timbers are set up by wedges. Under this system, work progressed at the rate of 14 ft. per day, with a cost of $24.41 per ft. in clay and $38 per ft. in rock. The amounts paid the contractors for extras aggregated $900,000, and in addition to this the completion of the work cost the city $150,000, making $1,050,000 above the original estimate of $400,000 for this section of the tunnel. In spite of this, however, the total cost of the lake and land tunnels, with pumping stations and pumping plants, will be within the original estimated cost of $5,000,000. The cost will be about as follows:

Lake tunnel and crib	$577,000
Land tunnel, Section No. 1	247,000
Land tunnel, Section No. 2	940,000
Land tunnel, Section No. 3	1,350,000
Pumping stations (two)	325,000
Pumping engines and appurtenances (six)	532,000
Total	$3,971,000

The only remaining work on the intake tunnel system is the proposed construction of a 10-ft. tunnel from the new Carter H. Harrison intake to the Two-mile intake of the Chicago Ave. tunnels. This would enable the Two-mile crib to be closed and abandoned. Its length would be 3,000 ft.

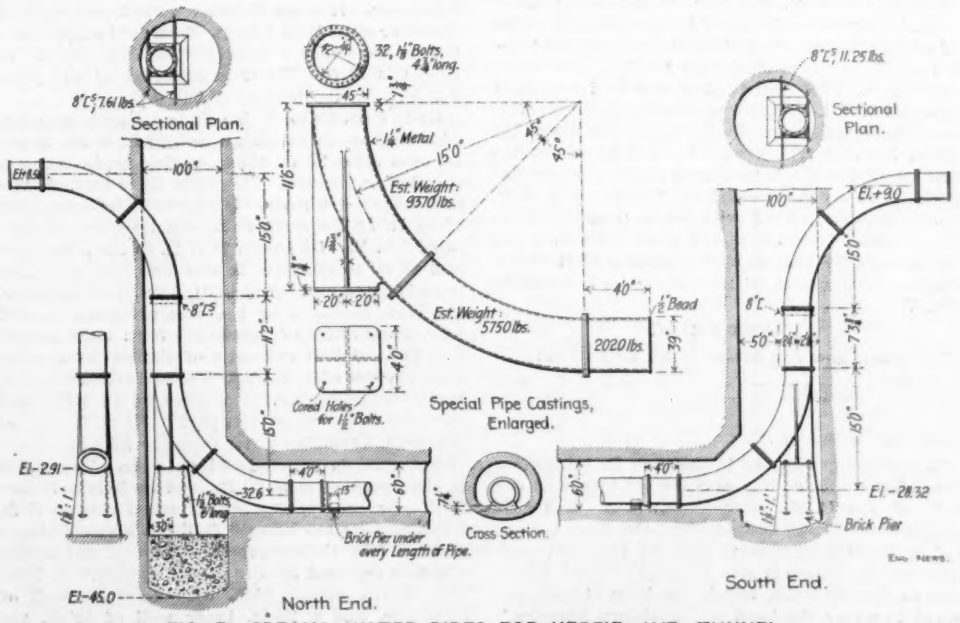

FIG. 7.—SPECIAL WATER PIPES FOR KEDZIE AVE. TUNNEL.

A connection between the new 10-ft. tunnel and the old two-mile tunnel system, was made in 1898 at the Chicago Ave. pumping station. This connection was designed to relieve the two-mile tunnels by furnishing water, in cases of emergency, by way of the new intake and tunnel to the pumps at the Chicago Ave. pumping station, and, incidentally, to lower the head pumped against at the Central, West and 14th St. pumping stations. If necessary, the new 10-ft. lake tunnel can supply at least

half the capacity of the Chicago Ave. pumping station, in addition to what is required by the two new pumping stations at Central Park Ave. and Springfield Ave. Plans for the installation of modern engines in the Chicago Ave. station and for the remodeling of the tunnel system at that point were prepared in 1898. This tunnel extension was done entirely by city labor.

RIVER TUNNELS.

When the distribution system was first extended across the river, submerged pipes were laid in the river bed, but after numerous accidents caused by ships' anchors, etc., the policy was adopted of building tunnels under the river to carry pipe lines as being safer and more economical. The first of these was built in 1869. There are now 16 of these short river tunnels for pipe lines, and most of them are circular, 5 to 7 ft. in diameter, but some are 9 × 6½ ft., and 10 × 7½ ft. Their length is from 200 to 400 ft.

The Western Ave. pipe tunnel was built in 1895 to accommodate the new 24-in. main on Western Ave. The tunnel is 404 ft. long, c. to c. of shafts, and is constructed through solid limestone. It is 9 × 7 ft. in section, which is sufficient to accommodate at least two 24-in. pipes. The tunnel is not lined with brick. In sinking the two shafts, on either side of the river, it was found that the stratum of sand overlying the rock contained water under pressure in such quantities that it was necessary to adopt the pneumatic process of construction, greatly retarding the progress and increasing the cost. This work was done by the city, Mr. W. D. Hotchkiss, Assistant Engineer, having charge of the construction of this tunnel.

The Kedzie Ave. pipe tunnel was built in 1898, to be used in connection with the new pipe distribution system laid during that year to carry a 36-in. main under both the Drainage Canal and the Illinois & Michigan Central. It extends from a shaft just north of the Drainage Canal to a shaft in 36th St., south of the Illinois & Michigan Canal, running about 100 ft. east of and parallel with Kedzie Ave. It is 7 × 6 ft., 1,548 ft. long. The erection of the working plant was commenced Nov. 25, and work on an intermediate shaft (No. 2) was begun Dec. 3. At a depth of 23 ft. below the surface, a seam of black sand, 12 ins. in thickness, was encountered. This was followed by hard blue clay, mixed with small stones and gravel, making progress extremely difficult. On Dec. 17, when a depth of 50 ft. below the surface had been reached, a spring of water was struck, making it necessary to lower a pump into the shaft before the length could be bricked in. When excavation was again resumed, it was found that there was a stratum of quicksand underlying the shaft, and after removing about 5 ft. of this it was decided to put in the brickwork for the bottom and sides at once, and begin work on the two drifts. The shaft is 10 ft. inside diameter, lined with three rings of brick. The surface elevation at this shaft is 13 ft. above datum, and the bottom of the sump is 41 ft. below datum. This tunnel, with its pipe line, is shown in Fig. 7.

INTAKE CRIBS.

There are now five intake cribs, as follows:

Lake View	2	miles
Carter H. Harrison	2⅝	"
Chicago Ave.	2	"
12th St.	4	"
Hyde Park, or 68th St.	2	"

The submerged intake in the 68th St. tunnel has been abandoned, as has also the old intake at the end of the U. S. outer breakwater. A 1-mile temporary crib was used on the Lake View tunnel, and a 2½-mile temporary crib on the Northeast lake tunnel. There is also an intake pipe 1,200 ft. long at Rogers Park, which has been already referred to under the head of "Auxiliary Supplies."

Two of the cribs, at Chicago Ave. and Hyde Park, are protected by outer cribs or breakwaters, leaving an annular space between the outer and inner cribs. Two of the cribs are fitted with steam-heating plants to prevent the formation of ice in the wells during the winter. At the others, the gate screens have to be removed before cold weather sets in, and during the winter a gang of 6 to 8 laborers with an engineman are required to break up and dislodge the ice in the well and remove it by means of a crane and hoisting engine, the blocks being discharged outside the crib by means of a chute. These men, of course, have to live at the cribs throughout the winter, adding considerably to the cost of maintenance. Telephone wires are laid to all the city cribs.

Chicago Ave. Crib.—This two-mile intake crib is hexagonal in form, and is surrounded by a hexagonal breakwater, which has an opening for tugs in the southwest face. This, however, allowed the ice and drift to get in and block the inlet ports, and in consequence of this when the Hyde Park breakwater was built it was made without any opening other than the ports, as noted below. In 1869 the water supply was entirely shut off for three hours by ice at the crib, but fortunately this occurred at night. In December, 1898, the anchor ice caused more trouble than ever before. For five days the keeper with a large force of men worked night and day to keep the ports open, and with such success that the water was at no time shut off. Steam jets have been placed in the suction pipes, so that the anchor ice cannot shut off the crib pumps. A connecting tunnel between the intake shafts of the Chicago Ave. (two-mile) and Carter H. Harrison (2⅝-miles) cribs is proposed, as already noted, and when this is built the two-mile intake would be abandoned.

Twelfth St. or Four-Mile Crib.—This crib is circular, 118 ft. diameter on top and 123 ft. on the water line, with a well of 70 ft. diameter. It is 50 ft. high, the top being 10 ft. above the water. There are two concentric ⅝-in. steel shells, with 24 radial bulkheads, forming compartments which are filled with concrete. This portion of the crib rests on a polygonal timber grillage 13 ft. high, through which pass six intake ports, 5 × 5 ft., fitted with gates and fish screens which are operated from slides in the middle of the circular wall of the crib. The intake shaft is 10 ft. diameter and has two gates, 5 × 6 ft., near the top. This structure was described and illustrated in our issue of July 5, 1890, and Sept. 15, 1892. In 1898, a steam-heating plant was installed and double windows were placed on the openings round the well. A temperature of 70° F. is maintained during the winter, so that it is no longer necessary to keep a force of men to remove the ice forming in the well.

Lake View Crib.—The present intake crib, 10,000 ft. from the shore, was set in 1892 by Shaller & Schniglau. It has a dodecagon steel caisson 72 ft. diameter outside and 36 ft. diameter inside, with a timber base and a masonry superstructure. Its height is 40 ft. Water is admitted by five ports, 5 × 5 ft., at the bottom of the crib.

Hyde Park Crib.—This crib is a timber structure of hexagonal form, with a well 30 ft. 6 ins. diameter and sides 25 ft. thick, having stone filling in the timber pockets. The sides have both shallow and deep-water ports. It has an outside diameter of 82 ft. at the main floor, and its sides are battered 1 in 12. Its height is 37 ft. to the lower floor and 46 ft. to the top. It was described and illustrated in our issue of May 31, 1894. This crib having been damaged by ice, was protected in 1895 by a breakwater of hexagonal form built around it. The original crib was of timber, having the pockets filled with rip-rap. The protection crib is of similar construction, with sides 34 ft. wide, and having a deep-water inlet port 5 × 7 ft. in four of the faces, admitting water from the lake to the enclosed portion, which is 34 ft. wide. The width of the breakwater is 30 ft., and its height is also 30 ft., its base resting on a bed of rip-rap 6 ft. thick, and its top being 9 ft. 6 ins. above Chicago datum. The timber superstructure of the intake crib was replaced by a masonry structure in 1896. This is two stories high, with an outer wall of limestone, and a 26-in. inner wall of brick, the space between the walls being filled with concrete to the level of the floor, 8 ft. above datum. The second floor is supported by I-beams and arch tiling, and above this is a dwelling-house. The well is covered by an iron truss roof with wire-glass skylight, and on the northwest side of the crib is an iron lighthouse, with a lantern 61 ft. above datum. The well is entirely enclosed, and in 1897 was equipped with a steam-heating plant, which maintains a temperature of 70° F. in the well during the winter, so that no ice forms. In consequence of this, the screens can be left over the gates, and only one additional man is required during the winter season, thus saving the cost of 8 laborers and an engineman formerly required for removing the ice from the well.

Carter H. Harrison Crib.—This structure, described and illustrated in our issue of Aug. 19, 1899, consists of two concentric steel cylinders, 60 ft. and 112 ft. diameter, on a timber base, and carrying a masonry superstructure, with dwelling-house and lighthouse. This crib, like two of the others, is equipped with a steam-heating plant to maintain a temperature of 70° F. in the well during the winter.

PUMPING STATIONS.

The first pumping station was at the foot of Chicago Ave., and was built in 1852-53. It was of brick, 40 × 50 ft., with two wings for boiler rooms 31½ × 40½ ft. The pump well was 20 × 30 ft., 25 ft. deep. The brick tower was 136 ft. high, 14 ft. square at the base and 11 ft. at the top. It had two compartments, one serving as a smokestack, and the other containing the iron stand pipe. The first engine was a vertical beam engine, with a steam cylinder 44 × 108 ins., and two single-acting pump cylinders, 34 × 60 ins. This was built in 1853 by the Morgan Iron Works, of New York, and others were installed in 1857 and 1867. The new pumping station, on the same site, was built in 1868-69, and is still in service. It is a two-story stone building, of some architectural pretensions, 142 × 60 ft. in plan, with a front projection 24 × 56 ft. The masonry tower is 154 ft. high, and the base is 22 ft. square, while the shaft is octagonal. In it is a 3-ft. iron stand-pipe 138 ft. high. Mr. W. N. Boyington was the architect.

The West Side pumping station, at 22d St. and Ashland Ave., was built in 1875, and has a stand-pipe 5 ft. diameter and 167 ft. high, enclosed in an ornamental masonry tower 190 ft. high.

There are eleven pumping stations, with equipment and capacity as follows:

1. Lake View Station (Montrose and Claremont Aves.).—Built in 1893. Four engines: One Worthington engine, 5,000,000 gallons capacity, erected in 1885; three Holly engines, 12,500,000 gallons, erected in 1888; 12,500,000 gallons, 1891, and 15,000,000 gallons, 1898.

2. North Side Station (Chicago Ave. and Lincoln Park Boulevard).—Built in 1866-68. Six engines: Three Morgan engines of 8,000,000, 13,000,000 and 18,000,000 gallons capacity, erected in 1853, 1857 and 1867; one Fort Pitt foundry engine of 36,000,000 gallons, 1872; two Holly engines of 12,000,000 gallons, 1887.

3. Central Station (Halsted and Harrison Sts.).—Built in 1888. Two Allis engines of 18,000,000 gallons capacity each, erected in 1889.

4. 14th St. Station (14th St. and Michigan Ave.).—Built in 1891. Four engines: Three Allis engines of 18,000,000 gallons capacity, one erected in 1891 and the others in 1892; one Lake Erie engine of 30,000,000 gallons capacity, erected in 1898.

5. West Side Station (22d St. and Ashland Ave.).—Built in 1876. Four Quintard engines of 15,000,000 gallons capacity; two erected in 1876 and two in 1884.

6. Hyde Park Station (Yates Ave. and 68th St.).—This was built in 1882, additions and alterations were made in 1892, and further additions were made in 1899. There are six engines: Two Holly engines of 12,000,000 gallons capacity, erected in 1886 and 1888; three Holly engines of 14,000,000 gallons, two in 1892 and one in 1898; one Worthington engine of 14,000,000 gallons capacity, erected in 1890.

7. Central Park Ave. Station (Central Park Ave. and Fillmore St.).—Built in 1899: Three Worthington engines of 20,000,000 gallons capacity, erected in 1900.

8. Springfield Ave. Station (Springfield Ave. and Bloomingdale Road).—Built in 1899-1900: Three Worthington engines of 20,000,000 gallons capacity, erected in 1900.

9. Washington Heights Station.—Built in 1885. Two Smith-Vaile engines: One of 400,000 gallons capacity, erected in 1885; one of 1,000,000 gallons, erected in 1888. The contract has been let for a Laidlaw & Dunn engine of 1,500,000 gallons capacity to replace the one erected in 1885.

10. Norwood Park Station (Drawing supply from artesian well).—Built in 1889. One Deane engine of 250,000 gallons capacity, erected in 1889.

11. Rogers Park Station.—Built in 1889. Two Deane engines of 1,500,000 gallons capacity, erected in 1889.

The following table gives the pumping capacity of the several stations, with the present engines, and with the additional engines contemplated or contracted for:

Pumping station.	Present No. of engines.	Pumping capacity, Present equipment, gallons.	Pumping capacity, Full equipment, gallons.
1. Lake View	4	45,000,000	64,300,000
2. North Side	6	99,000,000	99,000,000
3. Central	2	36,000,000	36,000,000
4. 14th St.	4	84,000,000	84,000,000
5. West Side	4	60,000,000	60,000,000
6. Hyde Park	6	80,000,000	80,000,000
7. Central Park Ave...	3	60,000,000	80,000,000
8. Springfield Ave. ...	2	1,400,000	2,500,000
9. Washington H'ghts..	1	250,000	250,000
10. Norwood Park	2	3,000,000	3,000,000
11. Rogers Park			
Total	37	528,650,000	588,750,000

QUESTIONS AS TO PROGRESS AND UNIFORMITY IN SIGNALING.*

We have several different methods of block-signaling; is such a variety necessary? Is the controlled manual worth what it costs? Is it needed on your road where manual block-signaling is now in effect, or can you prove that it is not? The men who sell signals seem to think that the railway manager frequently does not know what he wants. Can this be because his signal engineer has not grasped the subject on all its sides, or has been too modest to tell what the road needs? Probably not; for such managers usually have no signal engineers.

Do you and your manager fully agree as to what your road needs? How much money has been saved by the use of block signals on any particular road? Assuming that the direct money saving is rather hard to determine, what fact or argument should be presented to the manager who seems to think that block signals are unnecessary? The signal engineer whose manager does not appreciate block signals could do a good service to some of his fellow signal engineers by reporting that manager's views. A clear statement of them would help many a signal superintendent.

How many interlocking plants (at crossings) are on your road where the other road has certain standards different from yours? Which of the two standards is right? If yours is wrong, what can be done about it? What degree of uniformity do you find, as between your own road and others, in the matter of inspection and maintenance? I heard the other day of two roads practically side by side, one of which appeared to be spending about twice as much as the other on the care of automatic signals. It is imaginable that, if one has a much larger traffic and income than the other, a considerable difference in expenditure would be justifiable; but the subject would be a good one for discussion.

It may be that the time has not yet arrived for anyone to declare that all go-ahead signals shall be everywhere the same; but it is time that our stop signals should be uniform. Red should be always red and not dirt color, as is sometimes the case in day signals, or pale pink as is the case with some glasses in night signals. There ought to be agreement as to whether two stop-signals, neither controlling the other, shall be used close together, as for example a train-order signal near a semaphore block signal. And is it not desirable for men of different roads to confer as to a possible uniform distance for locating distant signals; not one unchangeable number of feet, but standard distances for like circumstances? When shall we agree as to what indicates caution? Shall it be a horizontal arm, notched; or an arm hanging down 45°; or one inclined 45° upward? What is the precise meaning of "caution" as applied to the fixed signals now in use? Uniformity of terms is not too small a subject to discuss.

On one road, the manager showed a saving of $30,000 a year in the accident account by adopting block signals. That is to say, for six years before the signals were put in, about that sum was spent yearly on account of collisions, while the next six years the expenditure was brought down practically to nothing.

Signals serve two chief purposes, to prevent collisions and to expedite train movements. The two purposes blend together. If your accident record is not bad enough to furnish a "frightful example" would you not do well to put forth your chief energies on the other branch of the subject? If all trains on your line are always on time, you may not be able to do much in this line of argument; but if there is any portion of the line, even a single mile, where a shorter time interval would enable your superintendent to do more business, there is the place where the space interval ought to be put in. Why wait until you have 50 miles that need block signals? Conservative managers look upon six or seven minutes as the shortest safe time-interval; but with block signals this can at once be reduced one-half or two-thirds. If six minutes is the shortest safe time interval, a reduction (by block signals) to three minutes doubles the capacity of the road. A three-minute interval has been maintained on some lines for years.

It is a question whether all the roads which have some signals, are equipping additional stretches of road fast enough. On the road that saved $30,000, the business has increased 60% in six years. Imagine the results of that increase if the block signals had not been put in. If business on your busiest line increases 25% in the next year or two, will your department be ready for the added responsibility?

How about block signals on single-track lines? Wherever it is proposed to build a second (or third) main track, there is an opportunity to try to show that this can be postponed for several years by spending a fifth or a tenth of the estimated cost on signal equipment for the existing tracks.

*Abstract of a paper written for the annual meeting of the Railway Signaling Club, by Mr. B. B. Adams, Editor of the "Railroad Gazette."

SELECTING LOCATIONS FOR AUTOMATIC SIGNALS.*

By C. C. Rosenberg.†

In making a survey for the installation of automatic signals, one of the greatest problems to be solved is that of location. Roads which have automatic signals find, that after signals are placed in service, some are to a great extent of little value owing to poor sight, stalling of trains, etc., and in some instances give confusing indications. In order to correct these, considerable expense is incurred which could to a large extent have been avoided if proper consideration had been given at the time of locating.

The following conditions should be considered: the relative relation of the signal to sight, passing sidings, crossovers, interlocking plants, junction points, passenger stations and length of block.

As all roads are not fortunate enough to have long tangents, it is often a serious problem to get a good sight for a location on account of obstructions or being placed in a series of short curves; it is often necessary to lengthen or shorten the block in order to get even a fair sight. The advantage of a home and a distant signal over the single-home signal is that trainmen are always in a position to know if the next home signal in advance is clear or against them, and can govern themselves accordingly. Signal bridges should preferably be used where there are four or more tracks, especially when the signals for both directions can be placed on the one bridge. Should this be considered too expensive, bracket poles can be used for four tracks. At passing sidings, the signals should be placed back of the fouling points of the outlet switch, so as to protect a train moving from the siding to the main track; while at the same time allow an approaching train on main track to advance one block further than if placed ahead of the switch. No signal should be placed immediately ahead of an outlet switch, and used as a starting signal; but in order to give a train moving from a passing siding a starting signal, it should be placed at a distance far enough in advance of the outlet that it cannot be mistaken by a train approaching on the main track as its signal. The proper location for a signal at the inlet of a passing siding is within 500 ft. of the switch points, and the next signal in rear should be placed not more than ¾-mile from the switch, preferably less, if it can so be arranged. Signals on the outside of curves should be avoided as far as possible; but if they are necessary, then the masts should be high enough so that the signals can be seen from approaching trains over the top of another train.

At interlocking plants automatic signals should be placed from 1,800 to 2,000 ft. back of the main line mechanical home signal, and the mechanical distant signal eliminated. The home signal on this mast should govern to the mechanical home signal only: the distant signal of this mast should not give a clear indication until the main line mechanical home signal is in the safety position, and the next automatic in advance is clear; this signal should be placed just beyond the interlocking limits. The main line mechanical signal should be slotted; should there be a diverging route to a high-speed track, the mechanical signal covering this track should be slotted also. In this case the distant automatic in the rear will display caution when the mechanical signal governing the diverging route is in safety position. This is not objectionable for the reason that trains about to take the diverging line are not allowed to proceed at full speed through the switches.

The placing of disk signals on masts with mechanical signals have been found to be unsatisfactory, especially where both home and distant are used. Indicators should be placed in all interlocking stations to give the leverman ample notice of the approach of trains.

At junction points where no interlocking devices are used, and where passenger and time freights connect with the main line, a signal should be located on the branch or connecting road near the junction point so as to give information to trainmen of the condition of the track on the main line after the route has been set up. In order to give extra protection to trains handling freight and passengers at stations, a signal should be located from 1,000 to 1,200 ft. on either side of the station; this will allow an approaching train to advance, and often avoid making a stop at the signal in rear, should a train be standing within station limits.

The length of block must be determined by traffic and track conditions. Where the traffic is not very heavy and the grade not more than 0.05%, one-mile blocks are considered very good practice. If traffic is congested, this distance should be reduced to from ½ to ¾ mile. On approaching ascending grades over 0.5%, blocks should be gradually shortened until a uniform length can be maintained, in order to avoid any unnecessary stops for following trains. On descending grades, blocks can be lengthened to conform to traffic and grade. In territory comparatively level and where traffic is not congested, blocks of 1½ to 2 miles can be successfully operated.

No location of a signal should be made just beyond a sag or apex, as a train obliged to stop at such a signal is liable to break in two in starting.

Before making a final survey it is well to consult with the engineering and traffic departments relative to track changes, such as changing locations of crossovers and siding switches, and in some cases present siding may be eliminated, thereby saving considerable expense if these changes can be made before signal work is begun. The transportation department should then be consulted, and the ground thoroughly canvassed, so as to determine definitely that the signals as located can be successfully operated from a traffic standpoint. It is also a good plan to get the views of competent enginemen as to locations, and ascertain from them if any are in localities liable to cause trouble.

In some foreign countries, the practice of locating signals for sight, is to use a full-sized templet of a mast and blade and send out a locating party. After a sight has been selected, the templet is placed in position and viewed from an approaching train. If not seen to a good advantage, the templet is moved from place to place until the best sight is obtained; this accomplisheed for day signals, the same process is followed at night, except that a light is placed on the mast instead of the blade. Very frequently, in making both night and day tests, it is found that the location which gives the best sight for a day signal may not answer for a night signal, which necessitates the selection of a new location. While this method may at first glance seem to be unnecessary, it is certainly well worth considering.

*Abstract of a paper prepared for the annual meeting of the Railway Signaling Club at St. Louis, Mo., Nov. 13-14.

†Signal Engineer, Lehigh Valley R. R.

A NEW KIND OF WOODEN WATER-PIPE.

Engineers are quite familiar, we believe, with the two sorts of wooden water mains which have been on the market for years, and which are commonly known as the Wyckoff pipe and the continuous wood stave pipe. A new kind of wooden pipe has recently been brought forward by a company at Spokane, Wash., and over 100,000 ft. of it have already been laid in Washington and Idaho. This new pipe is made like the Wyckoff pipe, in standard lengths, but instead of being cut out of a solid log in one piece, like the Wyckoff pipe, each length is made up of staves, wound with galvanized steel wire under tension. The sizes made are 2 to 8 ins., internal diameter. The staves are kiln-dried Oregon fir, ⅞-in. to 1½ ins. thick. Joints are made with a male and female socket on the small sizes and a sleeve and butt joint on the larger sizes.

Some 8-in. pipe of this sort wound with No. 4 copper wire has been tried in the mines of Butte, Montana, where the acid water rapidly destroys ordinary iron pipes, and with excellent results. This pipe has been tested to 500 lbs. pressure. The price of this class of pipe in the locality where it is used is said to be 15% to 50% below the price of iron pipe. The pipe is put on the market by the Spokane Galvanized Wire Pipe Co., of which Mr. J. C. Ralston is President.

FOUR PER CENT. BONDS of the Sanitary District of Chicago have been taken by the Illinois Trust & Savings Bank. The bank offered to take the issue of $2,270,000 at par, accrued interest, and a premium of $2,500. Bids for the bonds were first asked in September, when a syndicate of banks offered a premium of $2,500. This was considered too low, and new bids were advertised for, the issue being awarded to the New York Trust & Security Co. (the only bidder) at par, accrued interest, and $2,500 premium. The legality of the issue was contested, however, and the company imposed several conditions which led to the bid being eventually rejected, after which a bid was made by the Illinois Trust & Savings Co. and accepted by the Trustees. The bonds are in lots of 20, one lot redeemable each year for 20 years. The limit of the bonded indebtedness of the District is $15,000,000, and the present issue brings the outstanding indebtedness up to $14,585,000.

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The reduction in the average rate of interest in the United States during the past 20 years is one of the most remarkable economic changes that has ever taken place in this or any other country. It is a fact well worthy of note that at the present time U. S. Government bonds are selling at prices which net a smaller income to the holder than any which has ever been recorded for the securities of any nation at any time. The new 2% bonds due in 1930 are quoted at 104, which means that the net interest returned to a purchaser is only about 1¾%. But some of the earlier issues bring even less than this. The 4s due in 1907 are quoted at 114½ to 115, a price which nets the purchaser only about 1.60%, and there are still $341,348,000 outstanding. The climax is reached, however, in the 5% bonds due in 1904. These are now quoted at 114⅛, and at this price they net less than 1% on their present value; yet there are over $40,000,000 of these bonds still outstanding.

It is probable that the present holders of most of these bonds bought them at or near par, so that they are receiving on their actual investment a considerably larger interest than the above would indicate. It still remains true, nevertheless, that the holders of these bonds are content to keep them in preference to receiving the cash which they are at present worth in the market and investing it in other securities. There could hardly be a more convincing proof of the stability of the United States Government and of the financial strength of the United States as a nation than the simple fact stated above.

That the Stephenson link motion will give equal mid-gear leads on the forward and back centers provided the radius of the link is made equal to the length of the eccentric rods is a statement that has been repeated for many years by the text-books, and has been copied, probably, by one author from another without any attempt being made to prove its validity. Mr. Jesse I. Brewer, Assistant in the Engineering Department of Swarthmore College, has recently made a study of the subject, and finds that the statement is not quite correct, although the variation is too small to be of practical importance. Mr. Brewer has submitted to us an elaborate mathematical investigation of the problem, and the following is a brief abstract of the principal results obtained.

By graphical construction it may be shown that starting with a given length for the radius of the link and a given length of eccentric rods, decreasing the radius has the effect of increasing the mid-gear lead for the forward center and of decreasing it for the back center. There is, therefore, a radius for the link which will make the two mid-gear links equal.

It may also be shown that with a given length of eccentric rods and a given length of chord of the link, the sum of the two mid-gear leads, forward and back, is the same, whatever the radius of the link may be.

Mr. Brewer's mathematical treatment of the question leads to the following result:

Let

θ = angular advance;
r_1 = eccentricity;
r_2 = length of eccentric rod;
R = radius of link;
n = ratio of half chord of link to eccentricity;
$n r_1$ = half chord of link;
D = $2 n r_1$ = chord of link.

Then

$$R = \frac{D^2 + k}{4k} = \frac{D^2}{4k} + \tfrac{1}{4} k,$$

in which

$$K = 2R - 2\sqrt{R^2 - (n r_1)^2} = 2\sqrt{r_2^2 - (r_1 \cos\theta)^2} - \sqrt{r_2^2 - (n + \cos\theta)^2 r_1^2} - \sqrt{r_2^2 - (n - \cos\theta)^2 r_1^2}.$$

The formulas for the mid-gear leads are

$$L_1 = \sqrt{r_2^2 - (n - \cos\theta)^2 r_1^2} + R - \sqrt{R^2 - (n r_1)^2} - \sqrt{r_2^2 - (r_1 \cos\theta)^2};$$

$$L_2 = \sqrt{R^2 - n r_1)^2} + \sqrt{r_2^2 - (r_1 \cos\theta)^2} - \sqrt{r_2^2 - (n + \cos\theta)^2 r_1^2} - R$$

in which L_1 and L_2 are, respectively, the amounts by which the mid-gear lead exceeds the full-gear lead when the engine is on the near or forward center, and when it is on the remote or back center.

Applying the formula to cases in which values of the several variables are taken somewhere near practical values:

Let

r_1 = 2.5 ins. n = 2.4. θ = 18°.
$n r_1$ = 6 ins. D = 12 ins. $\cos\theta$ = 0.9511.
r_2 = 40, 60 and 80 ins.

The correct radii of links giving equal mid-gear leads are as in the table below.

Length of eccentric rods.	Radius of link, ins.	Difference, ins.	Lead—Back, ins.	Lead—Forward, ins.
40 ins.	39.7879	0.2121	0.3614	0.3615
60 "	59.8424	0.1576	0.2391	0.2392
80 "	79.9000	0.1000	0.1790	0.1790

Using a radius equal to the length of the eccentric in each case, the following leads are obtained:

Eccentric rod, length.	Lead—Back, ins.	Lead—Forward, ins.	Difference, ins.
40 ins.	0.3638	0.3591	0.0047
60 "	0.2390	0.2384	0.0015
80 "	0.1792	0.1788	0.0004

Thus, while it is theoretically incorrect to say that a radius of link equal to the length of the eccentric rod gives equal mid-gear leads, it is nearly enough correct for all working purposes in practical locomotive design.

A RAILWAY FREIGHT RATE OF 2 MILLS PER TON-MILE.

We have frequently called attention in these columns to the wonderful results achieved by American railways in the low cost transportation of bulk freights. A little over a year ago, in our issue of Aug. 17, 1899, we reviewed the remarkable record made by the Chesapeake & Ohio Ry. in the year ending June 30, 1899, when the very low rate was reached of 2.21 mills per ton-mile on coal shipped to the seaboard. The average rate on all coal shipped over the company's lines in that year was 2.74 mills per ton-mile.

It was claimed by critics that this figure represented abnormal conditions, and was, indeed, a minimum figure, representing the utmost possible in the economical movement of freight by rail. Concerning this matter, the New York State Committee on Canals, in its report presented last spring, said:

> We believe that the reduction in railroad rates which has been almost constant for the last 30 years, has received a check and that an increase may be looked for until the present prosperity shall be succeeded by depression, when it is probable that they will again decline; but it is very doubtful if they will go any lower, if as low, as the rates recently prevailing.

It is interesting to study this prophecy in the light of such facts as those which the reports of traffic on the Chesapeake & Ohio Ry. reveal. As we stated above, in the year ending June 30, 1899 the average amount received per ton-mile for all coal moved over that company's lines was only 2.74 mills.

But in the year ending June 30, 1900, this phenomenal figure was reduced by more than one-fourth, and the average rate per ton-mile on all coal shipped was only 2.02 mills!

"The Commercial and Financial Chronicle" in quoting and commenting upon these figures, well says: "They are perfectly astonishing, and but a short time ago would have been considered inconceivable."

Other figures in connection with this phenomenal record are of interest. We learn that the average rate on all freight carried over the Chesapeake & Ohio lines was only 3.43 mills per ton-mile. This may be compared with 3.62 mills in 1899, 4.25 mills in 1895 and 5.36 mills in 1892. In the face of this heavy reduction in rates the financial results to the company were better in the year under consideration than in any year on record. The gross earnings were $1,392,231 more than in the previous year, and the net earnings increased $381,976.

It will, of course, be asked how it was possible to increase earnings at the same time that such heavy reduction in rates were made. The answer is found in the increase in the average freight train load, which rose from 425 tons in 1899 to 488 tons in 1900. By this means an amount of freight greater by 18% was moved with an increase of only 2% in the total freight train mileage.

A further notable improvement was an increase of two tons in the paying freight load per car, making an average of 21 tons per car for all loaded cars moved over the company's lines during the year.

As we have before pointed out, it is the large proportion which the soft coal tonnage bears to the total traffic that is partially responsible for these phenomenally low average ton-mile rates on the Chesapeake & Ohio. On the other hand, the general freight traffic during the past year somewhat exceeded the coal traffic on this railway. It is evident, therefore, that other freight as well was handled at remarkably low rates, and still with an economy which left a profit for the railway company. Such results are the best possible proof of a very high degree of efficiency and ability in the managing officials of the company; and they show a development of the art of transportation which deserves more attention than it has received.

So far as we are aware, this is the lowest average rate ever recorded for the movement of bulk freights by rail; and the question at once arises, to what extent is such low cost traffic movement possible over other American railway lines. To answer this question we must consider the conditions which favor economical rail transportation.

The first and most important of these is volume of traffic. It was the increase of nearly one-fifth in the volume of traffic moved in 1900 as compared with 1899 that enabled the Chesapeake & Ohio to reduce its freight rates to such an unprecedented figure. The same principle holds on every railway. Where traffic is thin, rates must be high, or else the business must be done at a loss. Heavy locomotives, large capacity cars and long trains, which have done so much to reduce

the cost of freight transportation are only possible where a great volume of traffic is to be handled.

This is a matter which seems to be entirely overlooked by the advocates of waterway systems of transport. They fail to realize that the traffic diverted to the waterway makes it necessary for the railway to charge a higher rate on the remaining traffic. This is one of the cases where competition may cause higher prices rather than lower and an increase instead of a reduction in the final cost to the consumer.

Perhaps next in importance to volume of traffic among the conditions making possible cheap rail transportation, is low terminal expenses. It is coming to be well understood now that only a small part of the cost in handling freight is the cost of moving it over the open road. The great bulk of the cost of freight movement in many cases is the cost of getting it started on its journey at one end and of placing it at its destination at the other. Once made up in a train, it costs no more to haul a car of silk than a car of coal, but the former must be hauled for miles through a complicated network of tracks laid on land of great value, must stand for some time to receive its loading and must then traverse again the maze of tracks and switches and be hauled back and forth here and there by switching engines before it is made up in a train to proceed to its destination.

The coal, on the other hand, is loaded into the car by gravity near the mouth of the mine. The terminal tracks at the loading end can be of the simplest description, are laid on land usually of little value, and a whole train is loaded and made up at a trifling cost for switching operations. At the other end of its journey, too, the terminals are usually of a cheap and simple description, the cars are discharged rapidly and the total cost of handling is a trifle compared with the cost of moving cars through the tracks reserved for merchandise freight in a crowded city.

It must be clear from this illustration that the cost of handling general merchandise freights must of necessity be far higher than the cost for coarse bulk freights; and that the cost of terminal handling is an important factor in computing the cost of freight service on any road.

Comparing, for example, the New York Central with the Chesapeake & Ohio, it is probable that the former can haul its freight traffic on the open road at a less cost even than the latter on account of the very favorable grades and better rolling stock equipment. This advantage, however, is probably more than offset by the comparatively heavy expenses of the New York Central in handling freight at its Buffalo and New York terminals.

It will very likely be said that these phenomenally low rates made by the Chesapeake & Ohio last year were too low to give a fair return for the cost of service. We have alluded above to the fact that the financial results were the best to the company of any year on record, but it may be well to go into this matter more fully. Referring to the annual report, we find that the gross income of the company after paying all its operating expenses and taxes was $4,462,802. Interest on bonds and other debt took $3,306,221 of this, about $350,000 was spent for real estate and new equipment and $605,278 was paid as a dividend to the stockholders. The bonded debt is about $69,000,000, or at the rate of about $45,000 per mile. The amount spent from earnings for improvements was more than enough, we should judge, to maintain the property in good condition, and the total amount paid to bond and stock holders must be considered to be probably a fair return on the capital actually invested in the road. It is of course true that the stockholders received a dividend of only 1% as a result of the year's operations; but the question then arises whether the proportion of water in the stock really entitles them equitably to any larger return.

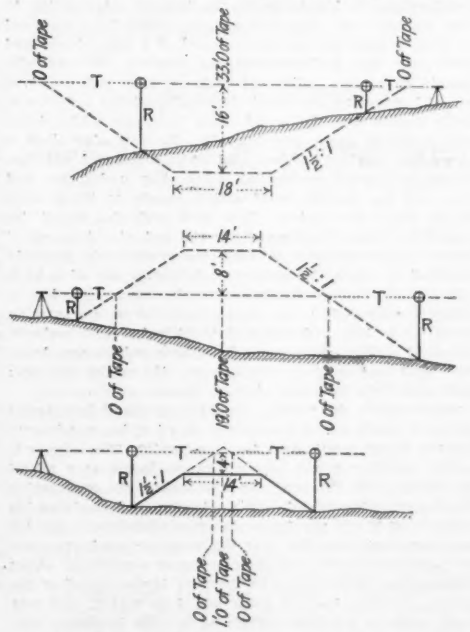
This brings us to a new point in the discussion: the reason for the prevalence of these phenomenally low rates on this railway. We need hardly say that such rates are not made as a voluntary matter or a matter of preference. Railway officers are trustees for the stockholders and their business is to reduce expenses and increase income, of course bearing in mind at the same time the obligations of the railway to the public. Such rates as those reached on the Chesapeake & Ohio, however, are reached only by stress of circumstances. The coal from the Virginia mines must be hauled a long distance to market, and except by a very low ton-mile rate on the railway, the coal mine operator cannot deliver it there in competition with coal from other points. The same thing is true with a large amount of other freight moving eastward to the seaboard. The Chesapeake & Ohio can only secure the traffic by making a very low rate, in competition with the numerous other trunk line routes. The remarkable rate of 2.02 mills per ton-mile on coal shipments and 3.43 mills on all freight moved are due, then, first to competitive forces and second to an efficient management which permits a profit to be made even at these low prices.

If these remarkably low rates were profitable in 1900, there is no apparent reason why they should not be profitable in 1901; but it is quite possible that the new factors which have recently entered into the problem may cause a radical change in conditions. Until recently, the Pennsylvania, the Baltimore & Ohio, the Chesapeake & Ohio and the Norfolk & Western have all been bringing soft coal to the Atlantic seaboard. Now, however, these companies, while still nominally independent, are under control of the Pennsylvania. That this combination may mean higher rates on soft coal shipments and higher prices to soft coal users is of course among the possibilities. For this reason, if for no other, the record of low rates made on the Chesapeake & Ohio last year is not likely to be soon reduced, but will probably stand for some time as a notable example of the possibilities in economical freight transportation by rail.

LETTERS TO THE EDITOR.

The Ward Tape and the Ordinary Tape in Setting Slope Stakes.

Sir: The reference to the Ward tape in the series of articles on setting slope stakes is of especial interest to me. In 1876 or thereabouts, this tape was used upon the Sudbury River Conduit of the Boston Water-Works, and was declared by all the fieldmen engaged upon that work a decided improvement upon the usual method of approximation and trial. I well remember the gratification it was to us to dispense with all calculations and let the tape do it for us, and I believe we covered about three times the distance in a day's work that we did with the old method. I do not believe anyone who has once used this method would give it up.



T : R = Horizontal : Vertical of Slope.

Examples of Slope-Stake Setting with Common Tape.

It is only a few days ago that I explained this method of cross-sectioning to an engineer in Wyoming.

Though the Ward tape is a great convenience, a similar method can be used with an ordinary tape and will greatly facilitate the work: Multiply the difference in levels between the instrument height and grade by the ratio of the horizontal to vertical of the slope, add to this product one-half the width of roadway. Find the number of feet on the tape denoting this sum and hold it at the center stake. Stretch the tape horizontally, at right angles to the line, and move the rod from the zero end of tape, toward the center line in the case of a cut, and away from it if a fill, until the reading of the tape and rod conform to the ratio of the slope, at which point set the slope stake. If the instrument height chances to be above the top of fill, subtract from half the width of roadway the product above referred to instead of adding; if the result is negative, it only indicates that the zero end of the tape should be held on the other side of the center line from the slope stake to be set. Respectfully yours,

Geo. T. Prince.

Omaha, Neb., Oct. 27, 1900.

Setting Slope Stakes.—A Reply.

Sir: I have read with much surprise the series of criticisms of my communication of July 19, culminating in a letter by Prof. J. B. Johnson, in which, it seems to me, he has gone far beyond the limits of controversial courtesy.

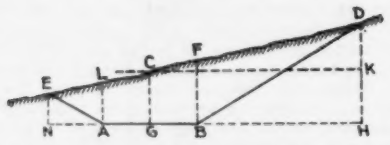
In my letter I referred to his book on "Surveying" (in the last edition of which he has done me the honor of introducing a method I proposed for the balancing of notes) as a "most valuable work;" and in my criticism of the method there taught for setting slope stakes I kept within the limits of politeness that should be observed by every writer who lays any claims to good breeding. Therefore, I consider his harsh language both unjust and uncalled for, besides being out of place in a discussion relating to purely scientific and technical subjects. Leaving this unpleasant personal matter out of consideration, I would like to say a few words concerning some more substantial and more worthy of notice criticisms of my letter. And first as to your "sermon" on methods of instruction in schools and colleges.

So far as I know, the "formula method" I suggested for setting slope stakes is not taught in any engineering school (the International Correspondence Schools included), and so your most edifying encyclical is open to the slight objection of irrelevancy. Nor was that method the outcome of my college education; for the professors of the Rensselaer Polytechnic Institute, of Troy, N. Y., under whom I had the good fortune of making my studies, taught me in the class room, and made me practice in the field, the very same method that I said in my letter was not an easy one for beginners. Therefore, that institution at least should not be placed under the ban on the dreadful charge of heresy. Furthermore, the evident aversion shown by yourself and other engineers to theoretical training, especially to the much-abused (perhaps because little known) mathematics, does not seem to me to be well-founded. The college graduate that has received a good training in engineering as a science (not merely as a bread-and-butter trade) does not require long to learn, or find out for himself, the little wrinkles and short cuts used in practical work; and an experience of two or three years is sufficient (other things being equal) to place him far above the man who has spent his life in "practice," but can rely on nothing but his field experience and his pocketbook. You say that foreign colleges have sunk too deep in mathematics and theory. But have you not been impressed by the great number of foreigners employed by all engineering concerns, especially for accurate and really scientific work? And have you not reflected that it is this cursed theoretical training that has made men like Rankine and Unwin in England, Bach and Weisbach in Germany, Morin, Darcy and Bazin in France?

I shall now turn to the more direct criticisms of my letter and formula. In the first place, it will be remembered that I proposed that formula mainly as a help to beginners, who, having had no experience in this kind of work, find a great deal of trouble with the trial method, before they train the eye and the imagination so that they can guess right. Probably I made a mistake in giving the derivation of the formula, as mathematical investigations, even if they are of the simplest character, are distasteful to the average "practical man," who at once sets them and the results arrived at by them down as theoretical rubbish. Stated in words, the method I suggested requires but these operations: (1) The measurement of a convenient distance out from the center stake; (2) the reading of the rod at the point thus determined; (3) the (mental) determination of the rise or fall in the distance thus measured; (4) the application of a very simple formula, which in the majority of cases can be worked out almost entirely mentally. The trial method involves practically the same operations, except that the distance first measured is a guessed distance, and that the formula applied does not give the final result, but serves only to test that distance. Of course, I know that the formula used in this case is very simple, and that after some practice, one learns to estimate distances and falls pretty closely. But is there no advantage in giving the beginner some certain method that he can rely upon, before he can rely on his experience? At any rate,

what harm is there in knowing two or more methods of doing the same thing? Surely, any one who tries several methods will be in a position to tell which is the easiest for him to use, and he may adopt the one that suits him best. Almost all my critics have condemned my method "on general principles," that is, because it is a question of mathematics and formulas; and they have insinuated that, because I suggested a mathematicl method for doing something that is done by eye "as easily as swallowing," I am not qualified to express an opinion on the subject. In answer to this charge I will say that Rankine, on pages 326 and 327 of his "Civil Engineering," gives no less than five formulas for setting slope stakes. So far as I am concerned, it is a sufficient consolation for me to be in the company of such men as he. The majority of your correspondents, however, will probably have no respect for Rankine; first, because he was a mathematician, and, second, because, as he was an Englishman, his methods lack the most indispensable requisite of "representing American practice." I shall, therefore, refer to an engineer whose competence will be readily granted by all my critics; namely, Mr. William H. Searles. As the subject is of importance, I hope you will allow me to quote in full the "formula methods" he gives on page 199 of his "Field Engineering" (16th edition). The accompanying diagram is taken from his book. He says:

When the natural slope F D or L E is uniform, its ratio s' may be found by measuring along the section the horizontal distance necessary to change the reading of the



rod 1 ft. (or half the distance necessary to change it 2 ft., etc.). Then, having found the depths of cut (or fill) at F and L, distant ½ b [= A G = G B] from the center C, we have [here s = slope ratio, and h = D H or E N]

$$B\,H = s\,h = s'\,(h - \overline{B\,F}),$$

and

$$A\,N = s\,h = s'\,(\overline{A\,L} - h).$$

From these we have, for the upper side in cuts, and lower side in fills [here x = C D],

$$h = \frac{s'}{s' - s}\,\overline{A\,L}; \quad x = \frac{1}{2}\,b + \frac{s\,s'}{s' + s}\,\overline{A\,L}.$$

We also have

$$h - \overline{B\,F} = \frac{s}{s' - s}\,B\,F; \quad \overline{A\,L} - h = \frac{s}{s' + s}\,\overline{A\,L},$$

whence the points D and E may be found by the level.

But points D and E thus calculated should have their positions verified by the general formula [x = ½ b + s h].

Now, let your correspondents aim their deadly weapons at Rankine and Searles, denounce them as incompetent, and brand the'r works as unfit for publication.

Antonio Llano.

The International Correspondence Schools,
Scranton, Pa., Oct. 27, 1900.

Mathematical Work in Engineering Schools.

Sir: I recall an incident in connection with slope-staking: It was at an Eastern university, where the cross-section rod was unknown; the instructor, a graduate from another Eastern university, was supposed to hold his appointment by reason of practical experience. The instruction was given by lectures; and, strange idea! setting slope-stakes—as easy as setting eggs on end—was among the topics considered; the rule for guessing more or guessing less was given in a sort of doggerel to aid the memory, if such be needed. Two parties, with A and B in charge, were sent out to set stakes along the same line, each to take every other station and unite on the fifth. A was new to the work, while B had some experience in teaching it; but the method he had been accustomed to was slightly different in some particulars, and besides, he either had forgotten it, or was determined to go by the new rule. Thus, while A made a fairly successful "stagger at it," B dropped into a state of thorough confusion from which the constant admonitions of the instructor and his hints at the simplicity of the task exemplified by the easy advance of the other party, were little calculated to extricate him. At the close of the day he found himself, in spite of all his industry, far behind A. However, he did not readily surrender, but determined to make his mathematics do the thinking for him.

By the following morning the instructor's rhymes had given place to formulas, the plus and minus signs now meant "guess more," "guess less"; and B rode upon his mathematical motor vehicle at almost breakneck speed, but with perfect ease and safety. Could you have seen the triumphant sparkle in his eye as, just before the village clock struck twelve, he passed his rival and took their last common station first, though not a word was said, you would have thought it vain endeavor to convince him of the futility of mathematics, in even minor matters.

If in your broad liberality you would grant to ordinary teachers of mathematics also the privilege of picking a flaw in your most orthodox and appreciated "sermon," I should ask if it would not be wiser instead of advocating the rejection of the abstruse higher mathematics to insist on their being made less abstruse—to insist on the use of "practical methods, short cuts and quick ways" in the teaching of them, since they are so evidently intended for the promotion of the interests of the profession. Should engineering schools, acting upon your suggestion, establish two courses, one in which the time spent in the pursuit of mathematics would "not result in more harm than good to the reasoning powers of the average student," and another, more advanced, would graduates from the two courses have accorded them equal opportunities, equal confidence, and equal chances for promotion, i. e., would they be "recognized either within or without the profession" as equally qualified for the work of the profession?

Once more, if the pursuit of abstruse mathematics is detrimental to the reasoning powers of the ordinary student, what is it, Mr. Editor, that could entice the understanding of advanced years and extended experience into a course of reasoning by which the competency of a man to speak for Americans, or judge of things American, would be determinable from the spelling of his name? Or, what could betray another into the conviction "that courage and patriotism and devotion rank higher in the world's service than scholarly finish and brilliant intellectual power?" If this is chargeable to the teaching of mathematics, high or low, let such teaching be discontinued. Very respectfully, Oscar Schmiedel.

Bethany College, Bethany, W. Va., Nov. 1, 1900.

Engineering Schools and Other Professional Schools Compared.

Sir: I am glad to see a revival in your columns of the discussion on engineering education, because, although the subject has been pretty well threshed over already, it is clear that the grain has not yet been separated from the chaff.

Perhaps it may help towards a solution of the problem—as it does of so many others—to work backward from results to causes. What are the results achieved by our engineering schools and how do they compare with those of other schools? For there are others. For instance, we have a school for military officers at West Point, and for naval officers at Annapolis. We have also a good many medical schools for doctors, all over the country. What results do these schools achieve? A four years' course at West Point qualifies an officer to handle a company of soldiers in the field, and to care for them in camp. He is competent, moreover, to take a rifle and show a recruit how to go through the manual, and to instruct an artilleryman in his duties in the battery. Annapolis, in like manner, will turn you out an ensign fully equipped to at once take his station on board of a man-of-war and fulfil all the duties pertaining thereto. He can also handle a marline spike and make a long splice. Four years' instruction at a medical school qualifies a doctor to bring people into the world, care for them while there, and facilitate their exit from it. He can also show a nurse how to tie a bandage and make a flaxseed poultice. All these schools accomplish what they undertake, and turn out the manufactured article, ready to be at once placed upon the market. How is it with the school designed to produce engineers? At the end of a four years' course, conscientiously pursued, the graduate is certainly qualified to teach elementary mathematics out of a book and a little applied mechanics in the same way, but is conspicuously unfit to act as an assistant on a surveying party, or to locate, design and build a dry stone culvert. He could not instruct a green hand how to hammer, dress, lay, bond and spall up the stones. He might not even understand the meaning of these terms.

Now, why is this? Why should four years' instruction suffice to teach a man how to cut off a leg, but not how to build a timber trestle or a dry stone wall? The answer is ready: the doctor was taught how to doctor at a school for doctors, but the engineer was not taught engineering at an engineering school. On graduating and receiving his doploma of M. D. the doctor can immediately put out his sign and begin practice, but the engineer graduate must on leaving school commence to learn something about engineering, by beginning at the very lowest round of the ladder. At best, he may get a job of surveying, and very likely make a precious muddle of it. He is almost certainly a bad draftsman, and probably very clumsy in adjusting an instrument.

Let us probe this matter a little deeper. From the day of his entrance at West Point or Annapolis, the instruction of the cadet in practical soldiering or sailoring commenced, and is kept up till the day of his graduation. The medical student is instructed in practical doctoring in the dissecting room and in the hospital at the bedside of the patient by the leading members of his profession. Is there any parallel to this kind of instruction in engineering? Take a case in point. There are several engineering schools in New York and its vicinity, and at all times gigantic engineering operations are in progress at their very doors. Are the students even so much as taken of a Saturday afternoon to look at them? Is the class in geology ever taken out on the ground to look at an outcrop of granite or limestone? Does not the student, on the contrary, acquire the impression that in some way his studies teach him all about engineering work without its being necessary for him to ever examine an actual structure? I believe this to be the case, and that the great mass of engineering students take very little interest in a real bridge or tunnel, or dam, but a great deal (if they are really studious) in the calculations pertaining to them.

I admit that the comparison of an engineering education with a military, naval or medical one, is not altogether fair. The scope of the last three is much more restricted than that of the former. "Engineering" is a very broad term, so broad that one is at a loss to state its limits. It is both a science and an art, while soldiering, sailoring and doctoring, will be found, I think, to be chiefly arts, besides being confined within very narrow limits as compared to engineering. It ought to be, and is, a longer and more complicated process to educate an engineer than a soldier, sailor or doctor. Still the fact remains that the proper education of the last three is better understood and more perfectly carried out than that of the engineer. The present and previous discussions prove this. We are still groping, in this respect, but are still achieving some good results. It cannot be denied that the student who has taken a course of study at a technical school is better equipped for the engineering profession than one who has not. It would be very discouraging indeed were it not so. Neither can it be denied, on the other hand that, as one of your correspondents has remarked, many of our leading engineers are, or have been, self taught.

I confess that although I have given the subject a good deal of thought, I am unable to reach a conclusion satisfactory to myself in regard to it, and what I have written above presents merely some of the crude ideas which have at times suggested themselves to my mind. The question turns largely upon whether the art or the science should predominate in the school education of the engineer. But our schools seem deficient in both branches. It appears to me that one of the difficulties is that pure science has not yet been sufficiently digested from the engineering point of view to produce the proper text books for the technical schools. I believe that the majority of our text books should be entirely recast, to adopt them to the needs of the engineer, as distinguished from those of the mathematician, the astronomer or the physicist. As an illustration of my meaning, I would cite "Bowditche's Navigator" as a model of the masterly adaptation of pure science to the practical requirements of a special class. More particularly is this true of mathematics. How utterly unsuited to the engineer as such are the text books on Analytics and Calculus, used in engineering schools. It is surprising that books only fitted for the use of the pure mathematician should be written by professors in technical schools and used in engineering classes. It would seem self-evident that the guide in preparing mathematical text books for engineering students should be to ascertain by a careful examination of engineering literature what amount and what kind of mathematics are employed by the leading authors in all countries, and to prepare books in conformity to these clearly defined lines. Taking even such passed masters of theoretical engineering as Rankine in English and Bresse in French, it is surprising how comparatively elementary is the most intricate mathematics which they "need in their business." Why go beyond the most advanced requirements? Why prevent the student from thoroughly mastering the indispensable elementary knowledge by consuming his time in giving him a very imperfect and superficial knowledge of what he has no need for? The engineer—and therefore the engineering cadet—requires but little mathematics, but that little he must know thoroughly. This fact seems to be pretty generally admitted, and yet it is systematically set aside in all our engineering schools.

As a parting word, let me ask why it is that the graduates of all our American technical schools are such conspicuously bad draftsmen, as compared with their European compeers? Why do we so persistently neglect the drawing board and the "squared paper" sketch book? These are towers of strength to the engineer at every step of his career, from beginning to end. If in preparing his designs he should first carefully sketch them out on squared or even plain paper, and then, with his own hands, draw them out in full on the drawing board, building up his work, as it were, in all its details on paper, he would avoid many mistakes and oversights which beset those who entrust their work to a draftsman, with only verbal instructions, and a hasty inspection when finished.

E. Sherman Gould.

Yonkers, N. Y., Nov. 3, 1900.

(As a matter of fairness, we should point out that visits of inspection to engineering works under the guidance of an instructor have been a feature of the work in a large number of engineering schools for a number of years. There has in fact been a great reaction away from theory and toward practice in all progressive American engineering schools; and as has already been pointed out, this reaction has in some cases gone too far.—Ed.)

The "Southern Review of Commerce" Again.

Sir: Herewith enclosed I send you a letter received from the "Southern Review of Commerce" and a copy of my answer to it. If it is possible that there are members of our profession who would use such means to obtain business, I think that they and their tempter should be publicly rebuked by honest periodicals, and if you agree with me I should be glad to see some comment upon this matter in Engineering News. You are welcome to use this correspondence, although I should prefer not to have my name published unless you think necessary.

Very truly yours, John Doe.

Philadelphia, Pa., Oct. 26, 1900.

(As many of our readers will doubtless remember the peculiar methods of the "Southern Review of Commerce" were pretty thoroughly exposed in our issues of Dec. 14 and Dec. 28, 1899. The concern appears to be still doing business—or attempting to do business—at their old stand and in the same old way. The whole correspondence makes such entertaining reading that we print it in full, as follows.—Ed.)

SOUTHERN REVIEW OF COMMERCE.

Editorial Department.

Louisville, Ky., Oct. 24, 1900.

John Doe,
Philadelphia, Pa.

Dear Sir: We enclose you herewith an editorial on the subject of Mechanical, Electrical and Civil Engineers which we know will be of interest to many of our readers, and we desire to publish it in the next issue of our paper. As your name is mentioned therein we ask that you make any corrections or changes that you think will strengthen the editorial and return us the manuscript as soon as possible.

We beg to call your attention to the policy of the Review (see letter head), and presume that you are acquainted with our paper.

As it might be of interest to you to distribute a number of these copies containing the editorial, we will furnish them to you at the following prices: 15 cts. per copy; 100 at 12 cts.; 250 at 10 cts.; 500 at 9 cts.; 1,000 or more at 8 cts. per copy; an order for 100 entitling you to a year's subscription without further cost. We have on hand a list of parties we know to be interested in your line, and if you so desire we will mail the copies to them and forward you the list, making no extra charge for postage, marking, addressing, wrapping, etc. Whether you wish any copies or not please correct the editorial and return as soon as possible. Awaiting your reply, we are,

Yours very truly, Southern Review of Commerce,
[Signed] R. F. Starr, Editor.

(Copy of "Editorial.")

A RELIABLE MECHANICAL, ELECTRICAL AND CIVIL ENGINEER.

The Review during the past eighteen years, has exercised the greatest care in investigating, gathering and editing such information as we may deem most serviceable and useful for the needs of our patrons. We have established a Bureau of Information, whose object is to secure accurate information ascertained through thorough research and exhaustive investigation, in regard to any manufactured product or the standing, ability or capacity of any firm, individual or corporation about which our readers may be in need of facts; and we used the same untiring efforts that characterized our past service in a recently conducted investigation, prosecuted to determine (in order to reliably answer subscribers who have requested a recommendation), which particular one of the many good mechanical, electrical and civil engineers in the United States is the best equipped through scientific attainments, ripe experience and high professional standing, to produce the most efficient plans in this line.

On making this present recommendation we deem it appropriate to state that the sources of our information were varied, the ramifications of our data extending in every direction, and we publish in our editorial columns, for the sole benefit of our readers, the unsolicited endorsement which follows:

We found that Mr. John Doe, of Stephen Girard Building, Philadelphia, Pa., is without doubt a most thoroughly reliable mechanical, electrical and civil engineer, and is an expert in just such work as our inquirers may desire to have done. Mr. Doe is well known for his business tact and enterprise, as well as integrity, and his standing in the commercial world is of the highest order.

Mr. Doe is an expert on power plants, special machinery, surveys and maps.

We disclaim any desire to advertise the above-named gentleman, and positively assert that this editorial is the expression of a conviction born of the acquisition of facts, and we advise our inquirers to communicate direct with Mr. Doe.

(Mr. Doe's Reply.)

Southern Review of Commerce,
Mr. R. F. Starr, Editor.

Dear Sir: Answering yours of 24th inst. Your "Bureau of Information" must be poorly equipped indeed if after "thorough research and exhaustive investigation" "to determine (in order to answer subscribers who have requested a recommendation), which particular one of the many good mechanical, electrical and civil engineers in the United States is the best equipped . . . to produce the most efficient plans in this line,"—if "the sources of (y)our information were varied, the ramifications of (y)our data" (whatever that may mean) "extending in every direction," and yet you only learned about a rather well-known engineer the facts stated in his professional card in "Engineering News" and other reputable periodicals, in addition to the stupendous fact (?) that he "is an expert in just such work as (y)our inquirers may desire to have done." As you "disclaim any desire to advertise the above-named gentleman," I do not understand your (seemingly contradictory) offer to furnish me copies of your printed recommendation at stated prices, or to mail them for me to your "list of parties" without extra charge.

I prefer not to be recommended by papers such as yours, and have not yet found it necessary to purchase recommendations nor to send them around by mail. I regret that you "used the same untiring efforts that characterized (y)our past services in" this "recently conducted investigation," and that a member of your staff expended literary energy in the preparation of this editorial. It is quite natural that you should not wish to publish it for anyone so inappreciative as I confess to be, and I have therefore retained your two-page manuscript. Should your writer need it, however, as a voucher for his next salary, please send stamped addressed envelope for its return.

Yours truly, John Doe.

Philadelphia, Oct. 26, 1900.

(By way of comment, we may add that in the building in which the offices of Engineering News are located, no less than four consulting engineers have recently received letters practically identical with the one sent to Mr. Doe and with the same old copy of an "editorial," submitted with the request for any "changes that you think will strengthen it."

If the "ramifications of Mr. Starr's data" are extending all over the United States with equal thoroughness, it speaks volumes for his discrimination in selecting "which particular one of the many good mechanical, electrical and civil engineers is the best equipped," etc., etc.

We have in our possession a large number of similar laudatory articles sent out broadcast by this "Southern Review of Commerce" to manufacturers and others with the invitation to buy extra copies; and it will be evident to any person of intelligence who examines the publication and its methods that whatever circulation it has consists of free copies paid for by the few who are silly enough to be duped by so transparent a fraud. We advise those among our readers and advertisers who receive such letters to forward them to the Post Office Department at Washington. The Department has power to exclude from the privileges accorded to second-class mail matter publications issued solely for advertising purposes: and this case would appear worth the Department's investigation.—Ed.)

BOOK REVIEWS.

MANUEL PRATIQUE DU YACHTSMAN.—Par Dr. G. Bedart, Architecte Naval. Paris: E. Bernard et Cie.,29 Quai des Grands-Augustins. Paper; 9 × 5½ ins.; pp. 560; illustrated. $3.00.

As the author well says in his preface, in yachting, theory is of some little service, practice is everything, and both can only be acquired by actually navigating your yacht. He therefore issues his manual as a guide in acquiring knowledge experimentally, and to explain the things observed in practice. As the manual is intended for amateurs, rather than for expert naval architects, the treatment is correspondingly simple. With this end in view, in separate chapters, he takes up the hull and its displacement, stability, etc., the sails and the effect of wind upon them, the state of the sea, tides, winds, etc., metallic and fiber rigging, and the various details of equipment. In succeeding chapters the author deals with the art of handling the yacht under various conditions, and gives much advice upon this head. It should be noted that the nomenclature is French throughout and differs widely from corresponding American and English terms.

SEWERAGE—The Designing, Construction and Maintenance of Sewerage Systems. By A. Prescott Folwell, M. Am. Soc. C. E., Associate Professor of Municipal Engineering, Lafayette College. Third Edition. Revised and Enlarged. New York: John Wiley & Sons. London: Chapman & Hall. Cloth; 6 × 9 ins.; pp. 435; 29 tables, 13 plates and 38 illustrations in the text. $3.

We are pleased to note that a third edition of this book has become necessary in so short a time. The additional matter consists of four chapters on sewage disposal, comprising 60 pages, and a two-page appendix summarizing information collected from city and sanitary engineers as to current practice in the ventilation of sewers, trapping of inlets and house connections, and the use of catch-basins. The chapters on sewage disposal present in brief compass the general principles involved, an outline of how those principles have been applied in a few instances and the results obtained, as shown by sanitary analyses and by financial accounts. Some readers will think the author has given undue space to chemical precipitation and not enough to the septic tanks and bacteria beds that are now receiving so much attention in England and America, but conservatism in this respect is very proper in a book designed to set forth well-established principles rather than claims for new processes, founded chiefly on small experimental plants or on limited or unrelated analyses of effluents from comparatively new and generally small permanent installations.

LES PORTS MODERNES.—Par C. de Cordemoy, Ingenieur des Arts et Manufactures. Paris: E. Bernard et Cie, 29 Quai des Grands-Augustins. Paper; 11¼ × 8 ins.; two volumes; pp. 583, 652, and one atlas, with 26 plates; 765 illustrations in the text. $10.

In the 37 chapters of this work the author goes into the detail of constructing, maintaining and operating modern seaports, regulating rivers, protecting the coast line, building ship-canals, etc. He commences with a discussion of the winds, tides, wave force, currents, sand-movement, and the other physical conditions effecting the location and maintenance of a seaport. He then takes up dredging, construction, light-houses, docks, the plant used in construction, the locks and their gates, quay-walls, and the buildings and machinery of the port. What makes this work especially valuable are its numerous illustrations of actual modern construction and location, introduced to illustrate the text. The larger part of these illustrations have the main dimensions placed upon them, and taken with the text, an enormous mass of useful information is thus gathered into two volumes. The last chapter is devoted to the cost of execution under a wide range of conditions. It is to be regretted, however, that the author has not seen fit to indicate by footnotes, or otherwise, the sources of his information, so that those wishing it could take up any special subject in still greater detail. But, on the other hand, the author has endeavored to make this work cover the whole range of modern harbor practice, and in many cases he goes into the most minute detail; and he has so far succeeded in his effort that the book is exceedingly useful for all seeking information in this direction. We know of no one work in any language that so completely covers the field.

THE PAN-AMERICAN EXPOSITION AT BUFFALO, N. Y., IN 1901.

(With two-page plate.)

When the gates of the Pan-American Exposition at Buffalo, N. Y., are opened to visitors on May 1, 1901, almost exactly 19 months will have elapsed since actual construction work was begun, on Sept. 26, 1899. It is quite likely that the opening date will not see the buildings and grounds entirely completed and the exhibits fully installed, but this is a perfection seldom reached in carrying out a large exhibition, and the Pan-American Exposition will, therefore, not suffer greatly in this respect in comparison with previous great fairs.

At present the outlook for the success of the exhibition seems equally favorable in other respects. Coming so soon after the Columbian Exposition at Chicago in 1893 and the succeeding smaller exhibitions at Atlanta, Nashville, Omaha, Philadelphia and elsewhere, some doubts have been felt by many persons about the value of another public show of similar character and about the possibility of arousing the amount of interest among possible exhibitors and visitors necessary to make it a financial success. To say that all doubts of success are now at an end would be very unwise, but it can be confidently said that the uncertainties are now no more than must always confront an enterprise of this character. The efforts of the exhibition managers have elicited the support and interest of manufacturers sufficiently to ensure a comprehensive range of exhibits, and the extensive publicity given to the plans and purposes of the exhibition has done much to incite that degree of curiosity in the sight-seeking public which the showman confidently depends upon to materialize in entrance fees. These are about as sound claims for success as any enterprise of the present character can ever present six months ahead of its consummation.

In view of the circumstances which have been briefly outlined, we have thought it of interest to engineers and manufacturers to describe concisely the plans and scope of the Pan-American Exposition and to summarize briefly the actual progress which has been made up to the present time. The information from which this review has been prepared was collected by a member of the editorial staff of Engineering News during a personal visit to the exposition grounds and by interviews with the managers of the exposition. The accompanying illustrations are reproduced from the o-

ficial maps and drawings of the engineers and architects of the exposition buildings and grounds.

HISTORY AND PURPOSE.

The Pan-American Exposition first received public recognition in a resolution endorsing its merits passed by Congress in July, 1898. On Jan. 19, 1899, the New York State Legislature passed a special act incorporating the Pan-American Exposition Co., with a capital stock of $2,500,000 and power to issue bonds for a like sum. On March 1, 1899, the same body authorized an appropriation of $300,000 to be used in making suitable exhibits on behalf of the state. On March 3, 1899, Congress made an appropriation of $500,000 to be used for a similar purpose in behalf of the United States. By Sept. 26, 1899, the financial and business organization of the enterprise had been completed, and the plans of the grounds and buildings had advanced sufficiently to permit the beginning of the actual work of construction. This work has continued uninterruptedly since that time, with results which will be described further on.

The purpose of the exhibition is to record the progress of the Western Hemisphere during the nineteenth century. It will concern itself strictly with the progress in industry, science and the arts of the countries of North and South America and their possessions. These countries were invited to participate in the exhibition by the U. S. Government in June, 1899, and official acceptances have been received from Canada, Mexico, Nicaragua, Salvador, Guatemala, Guadaloupe, Dutch Guiana, Bolivia, Argentine Republic, Chili, Costa Rica, Brazil, Peru, Venezuela and Haiti. Unofficial assurances of participation and support have been received of nearly all the other governments and dependencies of the Western Hemisphere.

LOCATION AND LAYOUT OF GROUNDS.

The grounds chosen for the site of the exhibition lie in the northern part of Buffalo, well within the city limits. Their length from north to south is about one mile, and their width is about half a mile. They contain 350 acres. Within the grounds is an irregular natural lake, which will become one of the principal water features of the exhibition.

The layout of the grounds for the purposes of the exhibition is clearly shown by Fig. 1. As will be seen, a broad thoroughfare runs north and south from near one end of the grounds to the opposite end. Near the north end this broad thoroughfare is crossed at right angles by the "Mall" so as to form a cross. These are the two main thoroughfares of the exhibition, and from them branch off all the minor walks and roads. The main entrance to the grounds is at the end of Lincoln Parkway, on the south side. There are also two entrances on the west side and two on the east side of the grounds, besides the railway entrance on the north side and the "water gate" on the south side. Besides the roads and walks there will be a canal, forming a complete waterway for launches and small boats, encircling the main group of exposition buildings. Except where taken up by the buildings and by the various thoroughfares, the grounds will be sodded and planted with shrubbery and trees. The landscape features of the grounds will also include as an important part a very comprehensive system of artificial waterways, and they have been worked out by Carrere & Hastings, architects, of New York city.

At the time of the visit of our representative to the grounds the grading of the areas to be sodded was practically completed except in the immediate vicinity of some of the buildings where the work of erection prevented it being finished. The sodding had been completed only for a very small portion of these areas, but the trees and shrubs were mostly in place. The basins for the fountains and lakes and the channel for the canal were excavated. The sides of these basins and waterways consist of sheet piling and the bottoms will be covered by a layer of broken stone. The roads and paths had been laid out and largely constructed, with the exception of the surfacing, a large portion of which was not finished.

THE EXPOSITION BUILDINGS.

The principal buildings of the exposition, as shown by Fig. 1, surround a broad court in the shape of an inverted letter T. The transverse portion of this court, known as the Esplanade, is 1,700 ft. long east and west, and the other portion, known as the Court of the Fountains, is 500 ft. wide and 2,000 ft. long. Entering the exhibition grounds the visitor passes through the main entrance at the termination of Lincoln Parkway and follows the main roadway leading to the Esplanade. The first building seen is the Albright Gallery of Art on the left hand. To the right are boat house and the main park lake. Crossing the bridge and continuing north the visitor comes to the approach and fore court leading to the Triumphal Bridge, which terminates in the Esplanade.

The buildings first seen upon the extreme right are the government group, consisting of three large buildings. On the far left is a similar group, consisting of the Horticultural, Graphic Arts and Forestry and Mines buildings. Crossing the Esplanade the visitor will approach the Ethnology Building on the right and the Temple of Music on the left, which mark the junction of the Court of Fountains with the Esplanade. On the right and

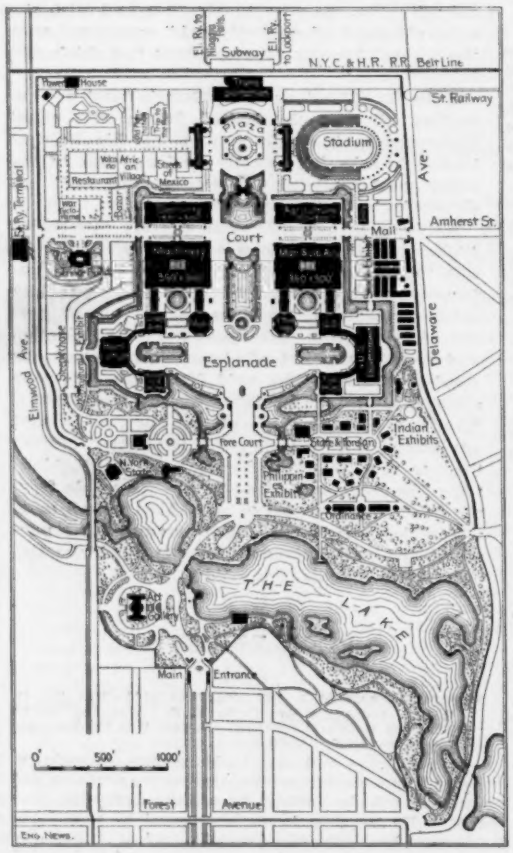


Fig. 1.—General Plan of Grounds and Buildings of the Pan-American Exposition.

left again are the subordinate Court of Cypresses and Court of Lilies. The aquatic basin in the Court of Fountains is 225 × 565 ft., or considerably more than two acres in area. This basin will contain numerous fountains and cascades. On the east and west sides of the Court of Fountains are the Manufacturers' and Liberal Arts Building and the Machinery Building, the two largest buildings of the exhibition. Continuing north the visitor comes to the Grand Basin, containing cascades and fountains, from the center of which rises the electric tower, 375 ft. high. East of the tower is the Agricultural Building, and west of it is the Electricity Building. North of the tower comes the Plaza, having a large band stand in its center, and which is closed in on the north by the Propylaea. The Plaza is 350 × 500 ft. On its east side is one of the main restaurant buildings and beyond this the Stadium, seating 10,000 people and inclosing the athletic grounds and race track. On the west side of the Plaza is a second main restaurant building, beyond which are the spaces devoted to the amusement buildings of the Midway. This Midway contains about 3,000 ft. of streets. The state and foreign buildings, to which about 15 acres are devoted, will be southeast of the main group and north of the Park Lake.

The general style of architecture of the exposition buildings is "a free treatment of the Spanish renaissance, which was adopted by the way of compliment to the Latin-American countries whose interest was sought and received in the enterprise." A fairly good idea of the appearance of the different structures will be obtained from the engravings of the several buildings given on our two-page plate. The buildings, with one or two exceptions, are constructed of wood covered with staff, but instead of being white like the buildings of the Columbian Exposition, they will be tinted and decorated in bright colors and with gilding. The roof covering will in all cases be red Spanish tile. The electric tower, because of its great height, will have a steel framework, but the covering will be of staff and tile like the timber structures. The New York State Building and the Albright Art Gallery are to be permanent structures and are to be built of steel and white marble. Numerous groups of sculpture will be employed to embellish the buildings and grounds.

The progress of work on the exposition buildings at the time the work was visited by our representative was about as follows: The wooden frameworks of the main buildings were completed or approaching completion and work was in progress erecting the staff covering and laying the roof tiles. Comparatively little had been done on the state and foreign buildings and on the various amusement structures bordering the Midway. Ground was just being broken for the athletic grounds and stadium, and the steelwork of the electric tower had reached a height of about 150 ft. Of the main buildings, the Government Building was in the most backward state and the Service Building was most advanced, being practically completed and in use.

PLAN OF EXHIBITS.

The exhibits of most particular interest to the readers of Engineering News are those representing the mechanic arts and engineering, and the plan and scope of these, so far as they have been determined, will be mentioned here only. Special prominence will be given the exhibits coming within the domain of electricity. Most of the exhibits proper will be contained in the Electricity Building, which provides 75,000 sq. ft. of exhibition space, but many of the other features, such, for example, as the use of electricity for illumination and exterior decoration and display, will be illustrated by the illumination and decoration of the electric tower and exposition buildings and of the fountains, canal and streets of the exposition grounds. The exhibition space in the Electricity Building proper will be devoted to three groups of exhibits, viz.: the service plant for the transformation and distribution of the 5 000 HP. transmitted from Niagara Falls for lighting and power purposes; a collective exhibit of historical interest, containing models and apparatus showing important advances in the development and use of electric power, and a commercial exhibit showing articles and devices of destinctive merit and usefulness. The following classifications of the exhibits into fourteen groups has been tentatively adopted: (1) Apparatus illustrating the phenomena and laws of electricity and magnetism; (2) Apparatus for electrical measurements; (3) Electric batteries, primary and secondary; (4) Machines and appliances for producing electric currents by mechanical power—dynamo-electric machinery; (5) Application of electric motors—elevators, power and railways; (6) Transmission and conversion of electric power—transformers and working models of transmission lines; (7) Systems of lighting by electricity; (8) Heating by electricity for domestic and mechanical purposes; (9) Electro-metallurgy and electro-chemistry; (10) Electric telegraphs, signals and wireless telegraphy; (11) The telephone and its appliances; (12) Electricity in surgery, dentistry and therapeutics; (13) History and statistics of development; and (14) Electricity in submarine work.

In the division of machinery the purpose is to have the exhibits representative rather than exhaustive in each particular line. Particular attention is to be devoted to displaying the newest and

best examples of special and automatic machines in various lines of manufacture. The display of steam engines is intended to include principally such distinct types as high and low speed, condensing and non-condensing, single and tandem, etc., in units from 100 HP. to 500 HP., such as meet the requirements of the ordinary user of power. In connection with these engines there will be shown typical boilers, feed water heaters, condensers, etc. Special attention has been given to the exhibit of gas engines, and engines of 500 HP. of this type will be shown.

In the department of transportation the special feature of the exhibits will be a comprehensive and complete display of motor vehicles of all classes. There will also be a good representation of street and steam railway cars, locomotives, steam and sailing vessels, etc.

One of the separate exhibits which, according to the present outlook, will be, perhaps, the most distinctive of the entire exposition in the mechanical line will be that of ordnance. It is estimated that seven years ago, when the Columbian Exposition was held, there were not more than half a dozen manufacturers of ordnance in the United States. At the present time there are about 150 manufacturers who are prepared to make exhibits in this department. The exhibits are planned to show the development of ordnance manufacture in the United States by displays of ordnance of large capacity, both for naval and shore batteries, machine guns of various styles and high powers, and small arms of all kinds. In the larger displays will be a pneumatic gun 50 ft. long, a section of a battleship with its equipment, and a model of a turret 52 ft. in diameter, and having 50 ins. of steel armor.

The display of agricultural machinery will be somewhat distinctive in the exhibition of small and simple motors designed to generate power for farm uses. In this department there will also be a comprehensive exhibit of road-making machinery, including graders, ditchers, rollers, stone crushers, etc. In connection with these machines there will be an exhibit of roads and streets in various stages of construction to illustrate the selection of materials and methods of construction. There will also be exhibits showing processes of drainage and irrigation and forms of farm fencing. The exhibits illustrating domestic and municipal sanitation and hygiene will be particularly complete in the lines of drainage, plumbing and garbage disposal.

In the division of manufactures the mechanical exhibits will include printing, engraving and bookbinding machinery, textile machinery, papermaking machinery, etc.

PUBLIC CONVENIENCES.

Transportation to and from the exhibition grounds will be provided by the trolley lines of the city and the Belt Railway line, with which all the steam railways entering Buffalo will connect. These street and steam lines are fully capable of handling much greater crowds than are likely to use them. For transportation about the exposition grounds there will be launches, gondolas, etc., plying on the canal, besides the usual brigade of wheel chairs, carriages, etc. As a matter of fact, however, the compact arrangement of the main exposition buildings render special conveyances unnecessary, except for those who are very poor pedestrians. The restaurant and toilet service will be particularly elaborate. At the main exposition restaurants, meals and lunches of all prices will be obtainable, and numerous privately-operated restaurants will provide for those desiring and willing to pay for special conveniences. A special police service will provide for the safety and protection of visitors.

OFFICIAL STAFF.

The executive staff by which all the work of the exhibition is personally directed is headed by Mr. Wm. I. Buchanan, as Director General. The Department of Works consists of the following officers: J. H. Murphy, General Superintendent of Building Construction; Rudolf Ulrich, Superintendent of Landscape; Samuel J. Fields, M. Am. Soc. C. E., Chief Engineer; Henry Rustin, Chief of Mechanical and Electrical Bureau; Luther Stieringer, Electrical Engineer; Henry Weatherwax, Chief Draftsman. The preparation of plans for the exposition is being carried out by a Board of Architects made up of the following persons: John M. Carrere, Chairman, of Carrere & Hastings, New York; John G. Howard, of Howard, Cauldwell & Morgan, New York; Walter Cook, of Babb, Cook & Willard, New York; Robert S. Peabody, of Peabody & Stearns, Boston; George F. Shepley, of Shepley, Rutan & Coolidge, Boston; George Cary, Buffalo; August C. Esenwein, of Esenwein & Johnson, Buffalo; Edward B. Green, of Green & Wicks, Buffalo. The electrical effects have been planned by Luther Stieringer, with Henry Rustin as engineer. The landscape plan and all formal landscape work, including bridges and approaches, are under the direct supervision of John M. Carrere, chairman of the Board. Rudolf Ulrich is the landscape gardener.

CONVERTING PORTIONS OF THE LOS ANGELES OUTFALL SEWER INTO A SEPTIC TANK.

A unique method of solving a serious and unusual engineering difficulty at Los Angeles is outlined in the accompanying letter to this journal from Mr. Frank H. Olmsted, City Engineer of Los Angeles, and described in detail in the able report which follows, made by Mr. Homer Hamlin, who is Mr. Olmsted's deputy. The outfall sewer in question was described at length in our issue of Feb. 28, 1895, while in our issue of Feb. 10, 1898, we published a brief article on the operation of sewer. After that date it became known that the mortar used for the brickwork of the outfall was disintegrating and the ironwork rusting badly, as was noted briefly in our issue of June 22, 1899, p. 389. Experiments were made with asphaltic and other coatings and a system of ventilation was proposed. Mr. Olmsted's letter, dated Oct. 26, 1900, is as follows:

The outfall sewer for Los Angeles, built in 1895, at an expense to the municipality of $340,000, and with a capacity of 30 sec. ft., has been deteriorating so rapidly the last two years as to occasion general alarm as to its stability and permanency. The design of the outfall included two inverted siphons, each over three miles long, made of wood stave pipe, and between them a brick-lined tunnel, where this rapid disintegration of the lining material was most pronounced. The gases generated by the detention of the sewage in its passage through the siphons, while acting as a preservative of the wood in the stave pipe, were simply eating out the life of the cement work, and the exposed metal surfaces. There were a number of remedies suggested, among others the construction of ventilating shafts every 300 ft. through the entire length of this tunnel structure. Mr. Freeman, who owns the Spanish grant through which the outfall is located, forbade the erection of any such vents to the sewer, and legally had the right to his position. The nuisance at the very elegant ranch house one mile away was at time reported to be unbearable; mechanical ventilation was barred by similar objection, and it seemed that the city was confronted by almost insurmountable difficulties in the matter. At this juncture, Mr. Homer Hamlin, C. E., Chief Deputy of the City Engineer of Los Angeles, made the following report and advised the transformation of the tunnel referred to into a septic tank. I was convinced that Mr. Hamlin had solved the problem by practically adopting the septic tank theory to actual relief of the unusual and serious difficulties in our outfall sewer, and immediately made requisition on the city council for $1,500 to do the work. This was granted Sept. 3, 1900, and proved sufficient in amount. The work was done while the sewer was in commission, and was turned over to the Superintendent, Mr. Derby, in its altered and completed condition Oct. 22, 1900.

The report by Mr. Hamlin was dated July 9, 1900, and addressed to Mr. Olmsted. We reprint the report practically in full, the only omission of importance being an account of the theory of the action of the septic tank, already made familiar to our readers, by matter printed in these columns and elsewhere:

As requested by you, I have examined the disintegrating mortar in the outfall sewer of the city of Los Angeles, and present herewith a report upon the condition of the same and the means proposed to prevent further decay.

The section of the sewer examined extends from the outlet of the first inverted siphon at Sta. 238 + 26 to the first drop chamber at Sta. 323 + 54.

The examination was as thorough as possible to make with the usual amount of sewage flowing in the sewer. The sewer was entered at five points. A more thorough examination should be made before the sewer is modified, but to do this it will be necessary to divert the sewage for a few hours.

In the chamber at Sta. 238 + 26, the outlet of the first inverted siphon, the mortar and plaster are rapidly disintegrating, and, unless the decay is checked, will soon damage the structure. In the 40-in. brick sewer below, the mortar is decomposed to some depth in the joints of the brickwork, but not enough to endanger the stability of the sewer. In the chamber at the upper end of the tunnel, at Sta. 257 + 20, the disintegration of the mortar is more pronounced, especially on the roof and sides of the chamber, and the arch of the 40-in. brick sewer which ends at this point. The mortar swells during disintegration to two or three times its original bulk. The force exerted by the swelling mortar is sufficient to break or spall off the brick in flat pieces. This takes place only when the disintegration of the mortar has reached a depth of 1 in. or more in the joints of the brickwork. There has been considerable of this spalling off of the brick on the under side of the 40-in. brick sewer arch, and as near as could be ascertained (as it was impossible to enter the sewer), fully one-quarter of the thickness of the wall has been destroyed. This seriously impairs the strength of the sewer and steps should at once be taken to prevent further disintegration.

There is far less disintegration of the mortar in the tunnel proper than in the 40-in. sewer, either above or below, except that the neat cement plaster on the sides above the water line is entirely disintegrated into a soft, wet, chalky mass, easily scraped from the wall by the hands alone. The mortar in the joints of the brickwork is not affected to a depth of more than ½-in., except in a few spots, far less than at the other points noted. So far as the stability of the tunnel is concerned, it is practically as strong as it ever was. The amount of disintegration diminishes in passing down the sewer until the first drop chamber is reached, at Sta. 323 + 54, where the sewage has a fall of about 12 ft. This fall and the consequent agitation of the water liberates a great deal of gas and vapor, which has seriously decomposed the mortar in the upper portion of this structure. It will be necessary to rebuild the roof and walls of this structure above the water line.

From the many examinations heretofore made upon the condition of the outfall sewer, it is evident that the disintegration of the cement mortar is caused by the chemical action of the sewer gases upon the hydraulic cement in the mortar.

As no determinative chemical tests have been made of these gases, it is impossible to state their chemical formulas or nature, but they are probably the usual gases given off by sewage during putrefaction, viz.: Nitrogen, carbureted hydrogen, light carbureted hydrogen, carbonic acid and carbonic oxide. "It must not be supposed, however, that decomposing sewage constantly emits any one of these gases in an isolated state, nor all of them in combination at any one time. The emanations assume sometimes one form, sometimes another, according to the nature of the organic substances in the sewage, its velocity, temperature, amount of possible oxidation, age and other conditions."*

The sewage in the outfall sewer is subjected to unusual conditions, namely, a slow passage under hydrostatic pressure through two long inverted siphons. The first siphon extends from the settling chamber, across the valley to the low hills near Inglewood. This siphon is 16,929 ft. in length, the lowest point of which is about 40 ft. below the inlet, 20 ft. below the outlet, and 30 ft. below the hydraulic gradient drawn from the settling chamber to the outlet.

When the usual amount of sewage (about 9 sec. ft.) is passing the settling chamber, it will require about four hours for the sewage to pass through the first inverted siphon, and the velocity of flow will not exceed 1.15 ft. per second, if the entire section of the pipe is open.

With so low a velocity, a large percentage of the suspended organic matter or sludge must settle to the bottom, where it decomposes or is broken up and carried out by the current in a finely divided state. These conditions are favorable for a partial putrefaction of the sewage. During this process, much gas is generated, which, however, cannot escape being retained in the sewage by reason of the hydrostatic pressure within the siphon, but which immediately begins to emanate from the sewage as soon as it is released from pressure at the outlet. A familiar example of water retaining gas under pressure is afforded in ordinary soda or carbonated water, which is charged with carbon dioxide under pressure. The gas immediately escapes from the water when the pressure is removed. By a similar process, all the gas generated during the putrefaction of the sewage while in the siphon is released in the sewer below.

The cause of the disintegration of the mortar in the brickwork is this concentration of the gases, and the presence of condensed moisture on the walls of the sewer. The examination made seems to warrant the following conclusions:

The vapor or moisture given off from the sewage condenses in drops upon the cold walls of the sewer, and is probably the only moisture which reaches the interior of the sewer above the surface of the sewage. The amount of moisture on the walls is at times almost enough to make them dripping wet.

The gases escape from the sewage at the lower end of the inverted siphon, when it is released from the hydrostatic pressure, and fill the sewer and tunnel below. By chemical affinity the elements in these gases unite with the oxygen in the air and form sulphuric acid gas, carbonic

*Van Nostrand's Science Series, No. 55, p. 12.

acid gas, etc. These acid gases, especially sulphuric acid gas, have a strong affinity for water, and by reason of this affinity a large proportion of the acid gases are probably re-absorbed by the sewage, and are so diluted that they are harmless, and in addition pass out of the sewer with the flowing sewage. Not so, however, with the portion of the acid gases which are absorbed by the drops of water which adhere to the walls of the sewer. These drops grow from the slow condensation of the vapor in the sewer and each drop remains about stationary until absorbed or evaporated. Since there is no constant change of water in these drops, as there is in the flowing sewage, and the absorption of the acid gases continues in the meantime, a point is soon reached when the acid solution is strong enough to attack and dissolve the lime in the cement mortar. A simple chemical test showed that these drops are intensely acid. A rough determinative test was made of the acid solution, and the efflorescence left upon the evaporation of the drops, both of which showed the presence of sulphuric acid and its compounds. This fact indicates that the corrosive or destructive agent is sulphuric acid. The compound resulting from the union of sulphuric acid, water and lime is sulphate of lime, or gypsum. This compound occupies much more space than the lime alone, and is the cause of the swelling of the mortar in the joints of the brickwork. There is no disintegration or change in the brick except the breaking or spalling off of pieces by the swelling of the mortar. This is purely a mechanical process and will cease as soon as the decomposition of the mortar is arrested.

As it seemed advisable to have an analysis of the decomposed cement, samples of the concrete, decomposed mortar and a sample of the brand of cement used in the construction of the sewer were submitted to Wade & Wade, Chemists and Assayers, for examination. The following is a copy of their report:

Los Angeles, Cal., July 9, 1900.

Mr. Frank H. Olmsted, City Engineer,
Los Angeles, Cal.

Dear Sir: We find that the sample of decomposed "neat cement" taken from the roof of the outfall sewer, has approximately the following composition:

	Per ct.
Silica	65.20
Iron and alumina oxides	0.75
Balance calcium (chiefly sulphates)	33.02
Free sulphuric acid	1.03

The iron, alumina and lime have evidently been dissolved out or changed into sulphates by the acid vapors and gases emanating from the sewage. The samples of concrete from the sewer, and cement from dealer, contain a slightly higher percentage of free caustic lime and calcium sulphate than are usually allowable in a good cement. However, this fact cannot be the chief cause of the decadence of the sewer, as acids of any nature will destroy the best quality of cement. Respectfully,

(Signed) Wade & Wade.

The average composition of artificial Portland cement is about as follows:

	Per ct.
Calcium, or lime	66
Silica	23
Alumina	7
Iron oxide	3
Magnesia	1
	100

A comparison of the amount of lime in normal cement and that in the decomposed cement in the sewer, shows that it has lost 80% of the original amount of lime, and that the balance has been changed to sulphates.

It may be of interest to note that the drops of water on the walls of the sewer can be observed in several different stages: (1) An ordinary drop of water, apparently pure; (2) an elongated and yellowish drop, which gives an acid reaction; (3) a pear-shaped drop, very much thicker than the last—in fact, almost viscous, and intensely acid; and, (4) a small, slender filament of sulphate of lime, which adheres to the wall after the combination of sulphuric acid, water and lime is completed. These filaments are easily brushed off, or fall from the wall and are carried away in the sewage. In this manner and by solution the missing 80% of the lime in the cement has been dissolved and carried away.

The amount of sulphur and sulphuric acid which has entered into combination with the lime is far greater, it seems, than the amount which could be possibly given off from ordinary sewage. It seems advisable to at once begin an investigation of the internal sewer system to locate, if possible, the source of this excessively great amount of sulphur. The only possible sources are acids from manufacturing plants, the sulphates in water, sulphuretted water from the oil wells, which flows into the sewers, and the sulphur which is always present in small quantities in normal sewage. Samples of sewage collected and analyzed should locate the point or points at which such compounds are being discharged into the sewers.

Owing to the extreme dilution of the acid in the sewage, and the rapid removal of the same, all that portion of the brick, concrete and mortar which is below the water line is perfectly sound, hard and entirely unaffected by the disintegration. It is proposed to take advantage of this condition, and prevent further disintegration by the means described below.

To secure the contact of the sewage with the walls, it is proposed to flood the sewer and tunnel from the lower end of the inverted siphon to the first drop chamber, by means of wooden dams or overflow weirs placed at three points, viz.: A dam in the manhole of Sta. 285 + 22; a dam in the chamber at Sta. 315 + 16; and a dam in the drop chamber at Sta. 323 + 54.

These dams have been so designed that they will raise the slack water slightly above the top of the circular brick sewer and tunnel at the highest points. By this means the escape and accumulation of gas is prevented, and the sewage being at all points in contact with the brickwork and mortar will prevent the concentration of acids upon the walls and will in addition dissolve and carry away all the acids now upon or absorbed by the walls, which are at present causing the decay of the mortar.

To prevent the oxidation of the gases, which process is necessary for the formation of sulphuric acid, the manholes and other vents on this section of the sewer should be closed air tight.

As the brickwork in the manholes above the water line will still be exposed to the action of the concentrated acids, it is proposed to line or sheath them with tongued and grooved lumber, on which the moisture and acids will condense instead of on the brickwork.

These acids with the moisture appear to act as a preservative in the case of wood pipe, as is shown by the perfectly sound condition of the wood stave pipe where exposed to similar conditions.

The dams, gates and other accessory structures may be easily and economically constructed of wood, and as they are either submerged or subjected to the same conditions as the wood stave pipe and the sheathing, they will not decay for a number of years at least. The rod with the ratchet, screw or other device for raising or lowering the gate should extend to and be operated from the surface outside of the sewer. This is necessary for the reason that the acids would soon rust a screw or ratchet and render it useless, while the section of a rod can be made large enough to allow for considerable corrosion.

It will be necessary to rebuild one of the structures, namely: the first drop chamber, as the disintegration of the mortar has already rendered the upper portion unsafe, and also to modify the chamber at the lower end of the tunnel.

The question which now arises is, what will be the result of damming up the sewage and checking its velocity during its passage through the 40-in. brick sewer and the tunnel. It is certain that the low velocity in the tunnel will allow the precipitation of the greater portion of the sludge, which will form an ever-increasing deposit on the bottom of the tunnel, and will have to be flushed out at frequent intervals unless the sewage and sludge are subject to septic decomposition as in a septic tank. The supposed changes which occur in a theoretically perfect septic tank are outlined below. (Omitted here.—Ed.)

The object in introducing a septic tank into a sewage disposal system, is the removal of the putrescible organic matter, especially that held in suspension in the sewage, known as sludge. It is necessary for the proper removal of the sludge that the following conditions be fulfilled: The sewage must be free from oxygen. The sewage must remain quiescent long enough to allow the precipitation of the sludge to take place. Time must be allowed the anaerobic bacteria to break down the sludge and finely divided organic matter held in suspension, and to so change their character that they may become soluble and will pass out of the tank with the clarified effluent. Sewage that will ordinarily reach a septic tank, having traveled some distance, will be practically free from oxygen, all having been absorbed in the process of decomposition which has already begun.

In England the usual practice is to build a septic tank large enough to hold the dry weather flow for 24 hours, but in America several such tanks are in use in which the sewage is in the tank four hours or less. The time necessary for the sedimentation of the sludge, and the complete action of the bacteria, can only be determined by experiment in each case. The action of a septic tank should be continuous.

If the sewer and tunnel are modified as proposed, will the conditions be favorable for the process of septic decomposition?

In answer to this question a comparison will be drawn between the conditions in a septic tank and the conditions which will exist in the outfall sewer when so modified.

As the sewage is stale when it reaches the settling chamber, and is not aerated in its passage through the chamber, or in its entrance into the siphon, the first condition necessary in a septic tank, the absence of absorbed oxygen, is obtained.

The second condition necessary in a septic tank is the precipitation of the suspended organic matter, and to secure this result it is necessary that the sewage be quiescent or move very slowly through the tank or pipes.

The following table shows the length, sectional area, velocity of flow, discharge and the time of passage of the sewage in the section of the sewer proposed to modify:

	Length, ft.	Sec. area, sq. ft.	Velocity, ft. per sec.	Disch., sec. ft.	Time, hrs., min.
Inverted siphon	16,929	7.86	1.15	9	4.0
40-in. brick sewer	1,893	8.73	1.03	9	0.31
Tunnel	5,805	20.4	.44	9	3.39
40-in. brick sewer	829	8.73	1.03	9	0.13
Total time from settling chamber to drop chamber.					8.23

The velocity of flow in the inverted siphon, 1.15 ft. per sec. will certainly permit the precipitation of the heavy portion of the organic matter, but not of the light, finely divided portion. With this velocity the sludge deposited will not remain long on the bottom of the pipe, but as soon as it begins to be broken up by the process of decomposition and becomes more finely divided, it is also carried along and through the siphon with the finely divided sludge which was not heavy enough to be precipitated. In addition, much of this heavy sludge is pushed or rolled along by the current, by which means the surface is constantly agitated, a condition not favorable for the development of the bacteria. The sewage enters the upper end of the siphon as ordinary stale sewage and is discharged at the lower end a dark, foul smelling liquid with the organic matter in a finely divided state, which shows that there has been a partial septic decomposition, and if the conditions below can be made favorable that the action would probably be completed.

Below the lower end of the inverted siphon there is a section of 1,893 ft. of 40-in. circular brick sewer, which it is proposed to flood. The velocity in this sewer when flowing full is 1.03 ft. per sec., which is not much of an improvement on the conditions in the siphon. However, as this portion of the sewer is built on a descending gradient, the sludge will be more readily pushed along by the current into the tunnel below.

The tunnel is 5,805 ft. long and has a sectional area of 20.4 sq. ft., which with the usual amount of sewage, 9 sec. ft. gives a velocity through the tunnel of 0.44 ft. per sec., when flowing full as proposed. This low velocity, less than half that in the inverted siphon, will certainly allow the precipitation of nearly all of the organic matter, and the current is so gentle that it does not seem probable that it will disturb the surface of the sludge. If these conditions are obtained, there seems to be no reason why the septic decomposition should not be completed. The time consumed by the passage of the sewage through the tunnel, 3 hrs. 39 mins., is a period long enough to allow the bacteria to break down the organic matter.

Below the tunnel there is 829 ft. of 40-in. circular brick sewer, which it is also proposed to flood. If the decomposition in the tunnel above is complete, there will be no sludge in this section, otherwise it will be in about the condition of the 40-in. brick sewer above the tunnel. It is impossible to predict what effect the extremely elongated form of the tank will have upon the development of the bacteria. Usually the septic tanks have a length of about five or six times their width, while in the tunnel the length is over 1,000 times its width and over 9.0 times its height. If different species of bacteria successively develop and feed upon the organic matter, this elongation by affording a means of more completely isolating each species may be a favorable feature and increase the efficiency of the tank.

Another question presents itself: What will become of the floating scum or mat which usually forms upon the sewage in a septic tank? The probable effect of confining this sewage in the tunnel will be that the floating sludge will accumulate at the manholes, if any is formed, although some may adhere to the roof of the tunnel. Judging from the condition of the sewage at the lower end of the siphon, this floating mat may not develop.

The purification of sewage in a septic tank is a partial process, and must be supplemented by filtration through sand or coke, or by broad irrigation. The conditions for broad irrigation are favorable in this case and there is no lack of irrigable land.

In conclusion, this statement may be made: The flooding of the sewer and tunnel will certainly prevent further disintegration of the mortar. This is not dependent upon the other phase of the subject, the disposal of the organic matter by septic decomposition, which if possible to obtain will greatly aid in the final disposition of the wastes of the city.

It is realized that the plan proposed is unusual, and may not be considered good engineering by some. It is also certain that no such structures would be planned in designing a new outfall sewer, but from the urgency of the case and from the fact that no damage will be done to any of the existing structures on the outfall sewer, it seems advisable to modify the sewer as above suggested.

The estimated cost of the proposed change is $1,000, but as it was impossible to examine the entire length of the sewer, an appropriation of $2,500 to $3,000 should be made, to provide for unseen difficulties.

AN IMPROVED GLASS "REVEALER," FOR STUDYING CONDENSATION IN STEAM-ENGINE CYLINDERS.*

By Bryan Donkin, M. Inst. Mech. Engrs.†

Some years ago the writer introduced a small glass instrument named by Hirn a "Revealer," for studying the condensation of steam in an engine cylinder. Since then some improvements have been made, and the following results obtained: A revealer was placed on the top of both the high and the low-pressure cylinders of a compound steam-jacketed vertical condensing, beam engine, working in a factory at a speed of about 35 revs. per minute. The diameter of the low-pressure cylinder is 26

*Condensed from a paper read before the Institution of Mechanical Engineers of Great Britain, Oct. 19.

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ins., with 3-ft. stroke, and that of the high-pressure cylinder 7 5-16 ins., with 14-in. stroke.

GENERAL DESCRIPTION.—Each revealer has two cylindrical glasses, Figs. 1 and 2, fixed concentrically one inside the other, thus forming a hot-air jacket for the inner glass, with an annular space of 0.4-in. between them. The inner glass cylinder is smaller in diameter than formerly, the connecting pipe to the motor cylinder is straight, and the cock and pipe much larger, so that the connection is more direct. Inside the inner glass is a small cast-iron cylinder. All the external metal and glass surfaces are well covered with removable thick non-conducting material to diminish radiation. The object of the instrument is to reproduce as nearly as possible, and render visible, what takes place inside the steam cylinder, and is necessarily concealed. No vessel, such as a revealer, exterior to the cylinder, can be under exactly the same conditions as the internal parts, because the cylindrical portion of the latter is cleaned by the piston at every half revolution, and the clearance surfaces are greasy. Nevertheless, the effects of condensation, as shown by the revealer, may be within 85 to 95% of the truth, and all results can be accurately seen, magnified, and studied. In all steam cylinders, condensation takes place on the internal walls when working with saturated steam. In this revealer, under the above conditions, very fine globules of water, the results of condensation, will be seen, close together, the appearance of which the author will first endeavor to describe for the low-pressure cylinder.

REVEALER ON THE LOW-PRESSURE CYLINDER.—The modifications of the improved revealer have caused a great reduction in the size of the minute globules on the glass walls, as compared with those shown in former experiments. After the revealer has become comparatively warm, and when the steam is first admitted into it from the low-pressure cylinder, the globules, from 1 to 2 millimeters (0.4 to 0.08 in.) in size, are much larger than those seen after working about 10 or 15 minutes, when all the parts have had time to acquire a normal temperature. Commencing with the steam stroke, the first result observed, when the steam is admitted to the revealer, is a light and not very dense cloud or white fog coming up from the engine cylinder. This is precipitated upon the hot internal glass and cast-iron walls, and is seen as very fine globules or particles of moisture or condensation. This cloud is sufficient to obscure a light placed on the opposite side of the revealer. Re-evaporation then rapidly follows before the end of the steam stroke. On the opening of the exhaust-valve, the cloud passes quickly off into the cylinder, and the glasses become quite transparent. A good illumination renders the incoming and outgoing clouds of mist quite visible.

Each time the steam enters, a large number of very small globules, at about equal distances from each other, are immediately seen upon the glass walls. These are from 1-20th to 1-25th of a millimeter (0.002 to 0.006-in.) in diameter, or less, and are distributed in a fairly uniform manner over the surfaces. The time occupied by the deposition of the globules, and their re-evaporation, is perhaps a tenth of a second. Before the end of the steam stroke, the duration of which is about half a second, and before the exhaust valve opens, the smaller globules, 1-25th of a millimeter in diameter, are all evaporated. During the exhaust stroke, the larger globules are also re-evaporated, but not so quickly. The internal surfaces are sometimes quite dry, and at other times a few drops of moisture remain on them.

To facilitate the study of these minute condensed globules or wet particles on the inside of the inner glass, a miscroscope is used, and the glass and iron walls well illuminated. It is interesting to watch not only the formation of the globules, but also their rapid disappearance by evaporation. Any change in the working conditions of the engine, by altering the expansion or speed, is at once detected. The globules change in diameter, becoming larger or smaller than before, probably as the difference of temperature between the walls and the steam is increased or diminished. Very soon, however, the glass walls take up a certain temperature, and constant conditions again prevail, differing only in the size of the globules from those previously seen. By artificially cooling the outside of the short iron connecting pipe between the glass revealer and the cylinder with cold water and a sponge, the fog or cloud on admission of the steam at the commencement of the steam stroke is much increased, as is also the diameter of the globules on the internal glass walls. The steam seems to be chilled.

Two other revealers with single glasses, and longer and uncovered connecting pipes fixed on the same end of the same low-pressure cylinder, gave during the same stroke greater condensation and larger globules, with thicker fog inside. This was a result which might be expected.

CONDENSATION ON THE CAST-IRON, FROM THE LOW-PRESSURE CYLINDER.—Inside the inner glass cylinder or revealer, a small cast-iron cylinder was placed, to observe the condensation produced on this metal, and to measure the size of the globules. Vertical and horizontal cross lines a millimeter apart were marked on this cylinder, forming small areas of one square millimeter, Fig. 6. These squares, being visible under the microscope, afford a useful means of estimating the size of the minute globules. The condensation observed was practically the same on the cast-iron as on the inner glass cylinder, both being probably at the same temperature, and touched by the same steam.

REVEALER ON THE HIGH-PRESSURE CYLINDER.—A second revealer, with double glasses and a small cast-iron cylinder in the center, was placed on the top of the high-pressure cylinder, and well protected from heat losses. All the general series of effects were the same as those on the low-pressure cylinder during one revolution. The only marked difference between the two cylinders was in the size of the condensed globules on the glass and cast-iron surfaces. These were about 1-4th to 1-5th millimeter (0.01 to 0.008-in.), some few being half a millimeter (0.02-in.) in diameter. This means more condensation in this cylinder than in the low-pressure, which agrees with calculation and experiment. This cylinder is jacketed with live steam at a pressure of 60 lbs. or about 4 atmospheres. With the low-pressure cylinder the pressure is the same in the jackets, namely 4 atmospheres; and as the mean working pressure is much lower than in the first high-pressure cylinder, there is a much greater difference of pressure and temperature between cylinder and jacket to keep the low-pressure cylinder walls hot. The jacket is more efficient on the low-pressure or globules of different diameters. These seem always to be in rapid motion, and not stagnant. On admission, the internal metal walls are heated by the steam. Other heat changes occur in each revolution, tending to equalize the temperature between the solid iron, the liquid water, and the gaseous steam.

Rotary engines should give less condensation on admission, as compared with the reciprocating types, both working with steam-jackets and with superheated steam.

STEAM REVEALER WITH INTERNAL STEAM OR WATER-JACKETED CAST-IRON CYLINDER IN CENTER.—The following further experiments have been made.

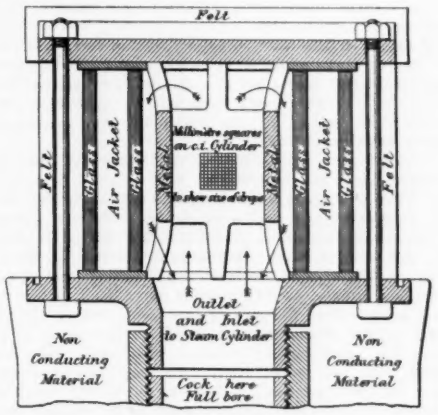


Fig. 1.—Section of Improved Revealer.

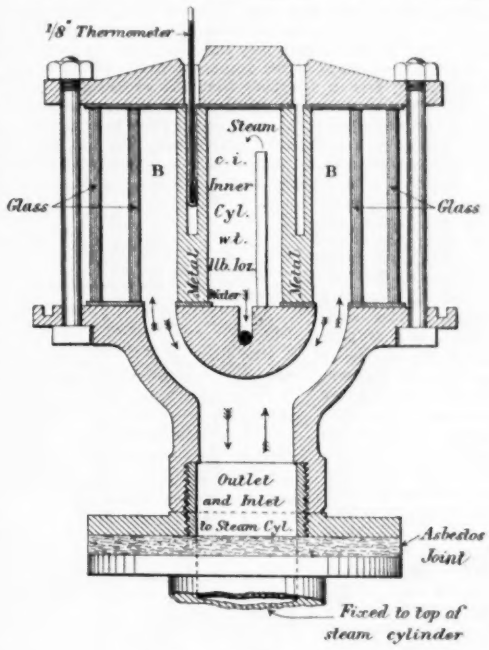


Fig. 2.—Section of Revealer with Internal Cast-Iron Cylinder.

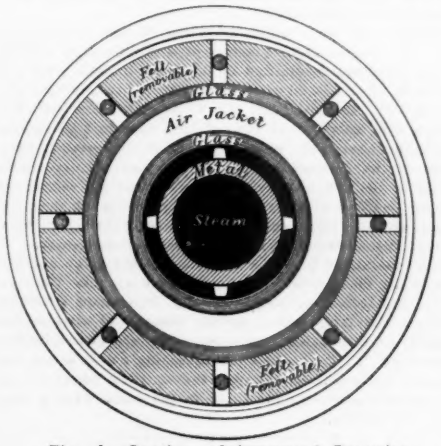
GLASS "REVEALERS" FOR INVESTIGATING CONDENSATION OF STEAM IN ENGINE CYLINDERS.

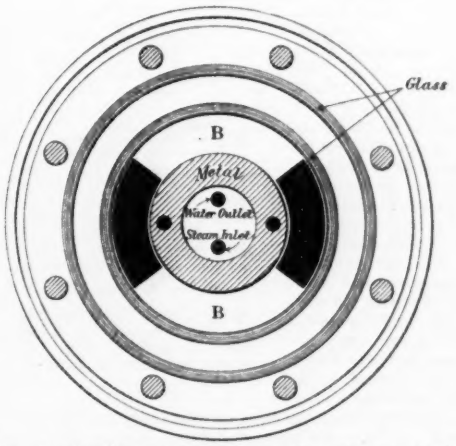
sure cylinder, and less condensation is to be expected. This agrees with experimental results.

To make sure that the varying pressures of steam in the revealer were really the same as in the engine cylinder, two indicators were fixed on the top of the revealer and the other on the top of the cylinder, and diagrams taken during the same stroke. The diagrams were exactly the same from the revealer as from the cylinder. The range of temperature in the high-pressure cylinder is generally about 101° F. or about 56° C., and that in the low-pressure cylinder some 85° F. or 47° C.; but the pressures and temperatures vary somewhat with the work.

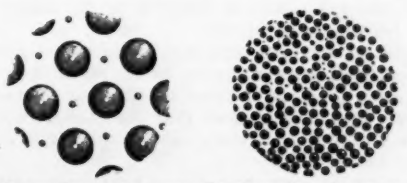
One result of these observations is to prove that there cannot be any thin film of condensation water on the internal surfaces of steam-engine cylinders, whether the cylinder is relatively hot or cold, as there has so often been supposed to be. The difference of temperature between the walls and the working steam seems to affect only the size of the globules of water. It is very difficult for the eye to follow the rapid and violent movements of fog and small globules of water in all directions on the internal surfaces, and also their very quick and violent disappearance by re-evaporation at exhaust.

It is now generally admitted that condensation of steam in engine cylinders is caused chiefly by the difference of temperature between the internal surfaces and the steam in contact with them, which it should be the object of engineers to minimize. Condensation is reduced in quick-revolution engines, and where dry or superheated steam is used. It assumes various forms, water particles, fog,





A small cast-iron cylinder (Fig. 2) is fixed in the center of the revealer, and so arranged that boiler steam can be introduced inside it to raise its temperature, provision being made to drain the water away. Cold water can also be passed through it continuously to reduce its temperature. The mean temperature of this inner cylinder is taken by means of a mercurial thermometer placed in a hole in the center of the wall. The steam from the



(a) Drops from high pressure cylinder. (b) Drops from low-pressure cylinder.

Fig. 3.—Appearance of Condensation Drops, Magnified 25 Diameters.

engine cylinder passes at each stroke into and out of the annular space BB, between the cylinder and the inner glass. The fog or condensation on the walls can be observed through the glass cylinder by the eye or a microscope. In this way the cylinder can be either heated by steam or cooled by water, and the fog effects noted for different temperatures of the small cylinder inside the

revealer. To get the mean temperature of steam in the steam-engine cylinder, indicator diagrams are taken, and the mean temperature calculated from the pressures. Thus, when all the conditions are constant, the temperature attained by the inner cylinder can at any time be compared with the mean temperature of the steam touching its walls.

The revealer shown in Fig. 2 was fixed on the top of the low-pressure jacketed cylinder of the engine, and placed in communication with it. The speed of the engine was about 35 revs. per minute. Boiler steam was admitted into the inside of the small central cylinder, and the revealer was kept going with the power on the engine constant for a given time until all the working conditions were normal. At a given moment, with the wall at 299° F. or 148° C., the steam was shut off from the jacket, and notes were made of the gradual decrease of the wall temperature, arising doubtless from the exposure of the hotter walls to the cooler steam-stroke, and to the still cooler exhaust-stroke to condenser. This had already been noticed in a preliminary experiment. The wall-temperature was read every minute until a minimum of 197° F. or 92° C. was reached and maintained. The steam was then turned again into the jacket, and the rapid rise of the wall-temperature noted up to 285° F., or 140° C. in about 1 minute. The wall-temperatures are plotted in Fig. 4. In 35 minutes the temperature of the cylinder decreased from 299° to 197° = 102° F., or about 2.9° F., or 1.6° C. per minute. The mean temperature of the diagram was 320° F., or 160° C. cooler than the mean temperature of the small cylinder walls. From the weight of the small cylinder, 1.06 lbs., its loss in thermal units per minute can be calculated. This amounts to 0.384 thermal units per minute, and for 0.095 sq. ft. is equal to 4 thermal units per sq. ft. per minute, lost by the walls to the condenser. In the above experiment there was very little radiation from the revealer, as it was just above a steam-jacketed and hot cylinder; and also very little conduction of heat along the connecting pipe, which is well covered, as is also the revealer.

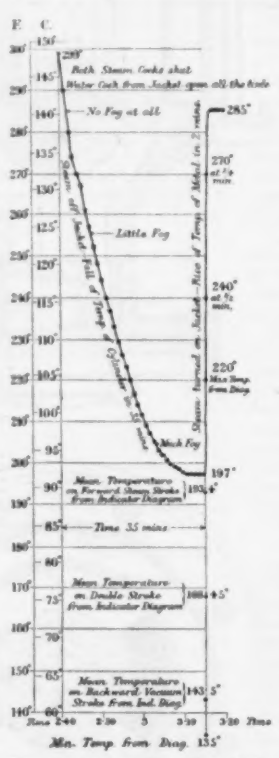


Fig. 4.—Curve Showing Fall of Temperature of Cast-Iron Cylinder (Fig. 2) When Exposed to Exhaust Stroke.

CONDENSATION OR FOG IN THE REVEALER.—With steam in the jacket no fog is visible, nor can any condensation on the walls be detected by the eye. They are much hotter than the incoming steam. About a quarter of an hour after shutting off the steam in the jacket a little fog is visible, and at the end of 35 minutes much fog is seen, and slight condensation on the walls; in other words, as the temperature of the walls was gradually reduced, the amount of fog and condensation increased.

In the concluding portion of the paper the author describes the most recent tests made in May last with a revealer like that shown in Fig. 2, except that the cast-iron chamber in the center of the revealer was square.

A set of six tests was first made to determine the different rates of cooling of the revealer cylinder after previous heating to different temperatures. The tests showed that the cast-iron surfaces absorbed heat more rapidly than it gave it up to the exhaust.

In the next tests, the rate of heat transmission was investigated with the internal cylinder previously cooled. The tests appeared to show that a greater thickness of condensed water on the wall of the cylinder did not appreciably reduce the rate of heat absorption. These results agree very well with the conclusions of the French investigator, Nadal, viz., that the heat-absorbing properties of cast iron are much greater than their heat-emitting properties, and the former are little influenced by the drops or condensation on the steam-engine cylinder walls.

The author has not yet made experiments with surfaces slightly oiled; all the above were carried out with fairly clean surfaces. A little oil from the steam cylinder might, perhaps, have been on them in places, but they appeared quite dry and even a little rusty to the touch.

In a discussion of the paper, by M. Nadal, it is pointed out that Mr. Donkin's original "revealer" probably did not show the actual events in the engine cylinder. With the improved type, when the walls of the "revealer" are placed in the same condition as the walls of the cylinder, Mr. Nadal thinks, "the phenomena of condensation in the steam cylinder are shown with almost perfect accuracy." The following comments are also of interest:

The experiments also yield very interesting conclusions with respect to the greater or less ease with which the heat penetrates or is given out by the cast-iron metal surfaces. As soon as the little cylinder was no longer heated internally, its mean temperature fell 102° F. in 35 minutes, or about 2.9° F. or 1.6° C. per minute. From this Mr. Donkin deduces the corresponding flow of heat. The weight of the little revealer cylinder being 1.06 lbs. the loss of heat (taking 0.113 as the specific heat of cast-iron) is 0.08895 calorie per minute, and, the external surface of this cylinder being 0.095 sq. ft., the flow of heat is 3.72 T.U. per sq. ft. per minute (or 0.17 calorie per square meter per second).

If the steam be again admitted to the jacket of the little cylinder, the mean temperature of the latter rises from 197° F. to 285° F. in about a minute (92° C. to 140° C.). The amount of heat which penetrates from the interior surface of the cylinder is therefore 2.668 calories per minute, this surface being 0.00487 square meter in extent. Thus the flow of heat increases to 547 calories per square meter per minute, or 9.11 calories per second, and is 54 times greater than the flow of heat given out by the external surface of the cylinder, as above calculated. This shows the extraordinary rapidity with which the heat passes from the jacket steam into the cylinder metal, while, on the other hand, it is given out slowly and with dimculty from a dry metallic surface in contact with steam colder than itself.

We may especially notice from Fig. 4 that, in the interval from half to three-quarters of a minute after the live steam had been readmitted to the little cylinder, the temperature of the latter rose from 240° F. to 270° F., that is, 30° F. or 16.65° C. Hence we may conclude that during this interval the flow of heat rose to 12.3 calories per square meter per second. From the theoretical equations of the propagation of heat we can calculate what would be the flow of heat per square meter per second per degree Centigrade difference in temperature between the steam and the metal surface in contact with it; in other words, the coefficient called the "absorbing power." If this be calculated in terms of the equations given above it should be 36 calories (in English units: 7.38 T.U. per sq. ft. per second per degree Fahr.) The mean difference between the temperature of the steam and that of the metallic surface during the interval we are now considering is 0.34° C. Thus while the absorbing power of the wet metallic surface is 36 calories, the emitting power of the dry metallic surface, calculated in the same way, is only about 0.1 calorie.

TRACKLAYING ON THE ATCHISON, TOPEKA & SANTA FE RY.

The San Francisco & San Joaquin Valley Ry. originally had its northern terminus at Stockton, Cal., on the San Joaquin River, with steamboat service between that place and San Francisco. Since the acquisition of this line by the Atchison, Topeka & Santa Fe Ry. it has been extended 70 miles to Point Richmond, on San Francisco Bay, whence large steam ferryboats connect with the city. With this new line and its extension the Atchison, Topeka & Santa Fe Ry. has its own line from Chicago to San Francisco, 2,592 miles.

In the construction of the Point Richmond extension, some rapid work of construction and tracklaying has been done, for the following particulars of which we are indebted to Mr. W. B. Storey, Jr., M. Am. Soc. C. E., Chief Engineer of the Atchison, Topeka & Santa Fe Ry., who was formerly Chief Engineer of the San Francisco & San Joaquin Valley Ry. The tracklaying was all done by hand, and the general characteristics of two pieces of this work are tabulated in the accompanying table.

The method of tracklaying was as follows: The boarding outfit was generally spurred out to one side. The tracklaying train carried out each morning enough material for one mile of track. This consisted of 4 cars of rails and 6 cars of ties, together with the pioneer car and tool car. The train was made up as follows: Pioneer car, 2 cars of ties, 2 cars of rails, 3 cars of ties, 2 cars of rails and the tool car. The train was pushed to the front, a certain amount of rails and ties unloaded, and the train then pulled back. The material was then loaded on iron cars or push cars, the rails ahead and the ties behind. The ties were carried around the rail car and distributed, after which the rails were thrown in place and the rail car and tie car moved forward, this being repeated until the loads on the iron car were exhausted. Strappers and spikers followed the iron cars and partially spiked and bolted the track before the train came upon it. As soon as the material unloaded from the train onto the push cars was distributed and laid, the train was again pushed forward and another lot unloaded. The iron cars were pulled forward by a single horse. The force employed was about as follows:

Tracklaying foreman ..	1	Tie plater	1
Sub-foremen	3	Distributing spikes	1
Strappers	4	Spacing ties	2
Iron car men	10	Spacing rails	2
Spikers	8	Back bolting	2
Nippers	4	Tie carriers	10
Tie line man	1	Picking up scattered materials.	1
Lining ties	2		

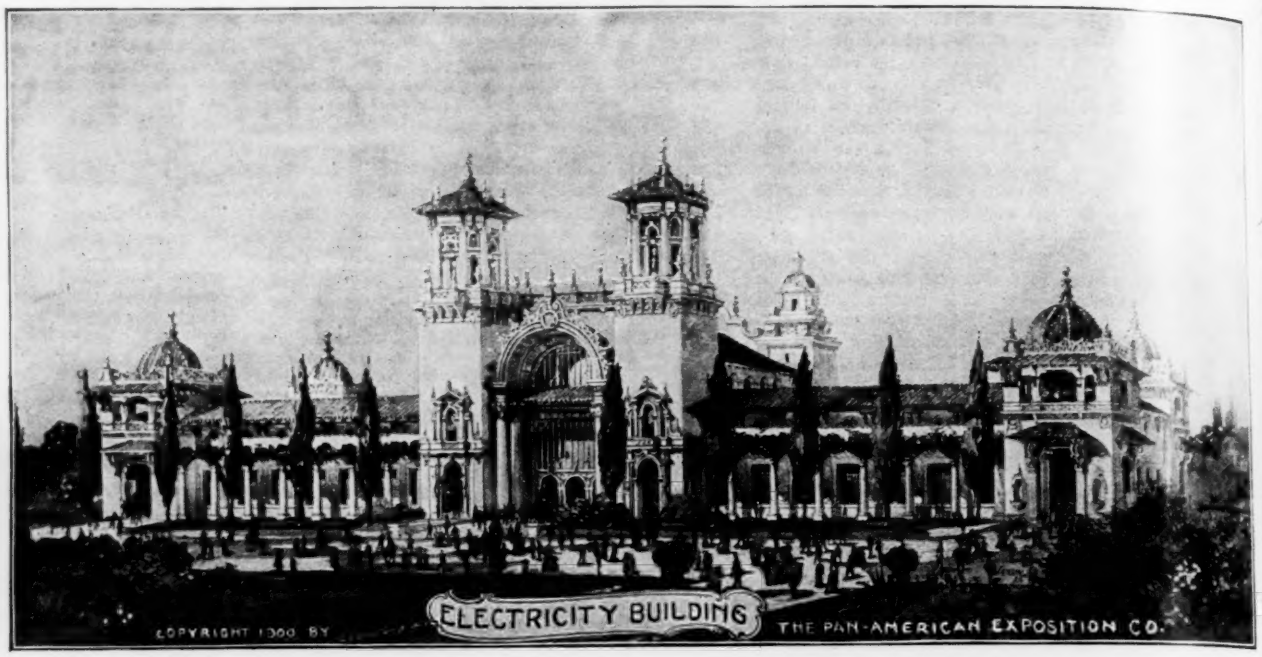
This force was kept as nearly constant as possible, but owing to the usual fluctuations, there were sometimes more and sometimes fewer men. All of the above track was laid with ties which had been tie-plated in the material yard before being sent to the front. The tie-plates under the joints had spike holes punched to a different spacing from those used elsewhere under the rail, and as the track was laid, it was necessary for a man to attend to taking out the ordinary plates and replacing them with the joint plates. He also had to replace any plates which might have shaken out during transfer to the front. This was the duty of the man called the "tie-plater." The rails were all curved in the yard before being forwarded to the front.

The iron car men attended to unloading the rails from the flat cars and loading them on push cars. They also handled the fittings, such as splices and spikes, until it came to distributing, when an additional man was used for distributing spikes. The men who handled the rear end of the rail were known among the track men as "heelers." They unloaded from the iron car the splices at the proper places.

It will readily be understood that it is sometimes hard to get a force organized to act to the best advantage, for the reason that interruptions occur on all new work, such as the erection of bridges, delay in grading, etc., so that frequently track is laid to fit these delays rather than to obtain the fastest and cheapest work in regard to tracklaying alone. In certain parts of the work in the San Joaquin valley there were long stretches of 30 or 40 miles where track could be laid continuously, and the work would then come up against a bridge that would take from six weeks to two months to erect. In other places only 10 or 12 miles could be laid, and the work would then have to wait for the erection of bridges. Part of the work was laid by having ties distributed ahead with teams, but on certain portions it was impracticable to do this, and the cases mentioned in the above table belong to the latter class.

In regard to the surfacing, it was the custom to have a gang following the tracklaying gang, and the surfacing was done by taking material from the corners of the bank and throwing between the ties and using it for tamping. In some cases, however, material for surfacing purposes was hauled onto the track, there being no ballast which could be obtained at hand.

Date	Oct. 9-25, 1899.	Feb. 20 to Mar. 30, 1900.
Track laid	10.74 miles.	16.6 miles.
Average laid per day..	2,846 ft.	3,503 ft.
Maximum laid per day	5,400 "	4,500 "
Rails	62½-lb.	75-lb.
Joints	Broken.	Broken.
No. ties on tangents...	17 per rail.	17 per rail.
No. of ties on curves..	18 per rail.	18 up to 4°, 19 beyond.
Grade	Practically level	Des. 1%, with curves, ½ mile .....
Embankment	Average, 10 ft.	
No. of men, average ..	44.6	47.9
For max. day's wrk	57	52.6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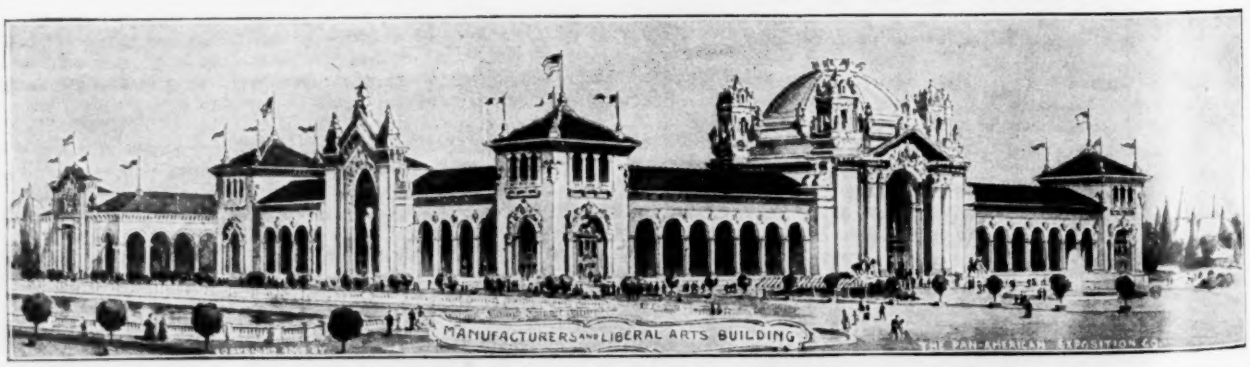
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TYPICAL BUILDINGS
of the
PAN-AMERICAN EXPOSITION, BUFFALO, N. Y.

Wm. J. Buchanan, Director General.
Samuel J. Fields, M. Am. Soc. C.E., Chief Engineer.
John M. Carrere, Chairman Board of Architects.